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FINAL REPORT

Mojave Fringe-toed Lizard (*Uma scoparia*) Surveys

at the

Marine Corps Air Ground Combat Center, Twentynine Palms, California

&

Nearby lands administered by the Bureau of Land Management

Desert Research Institute, Reno, Nevada, and
University of Redlands, Redlands, California

PROJECT FUNDED BY:
NATURAL RESOURCES AND ENVIRONMENTAL AFFAIRS DIVISION
UNITED STATES MARINE CORPS
MARINE AIR GROUND TASK FORCE TRAINING COMMAND
TWENTYNINE PALMS, CALIFORNIA

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Cablk, M.E. and J.S. Heaton, 2002.

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Contract # M67399-00-C-0005

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Recommended Citation:

Cablk, M.E. and J.S. Heaton. 2002 Nov. Mojave Fringe-Toed Lizard surveys at the Marine Corps Air Ground Combat Center at Twentynine Palms, California and nearby lands administered by the Bureau of Land Management. California: Marine Corps Air Ground Combat Center. Report M67399-00-C-0005. 115 p.

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EXECUTIVE SUMMARY

The Mojave Fringe-toed lizard, *Uma scoparia*, is a California Department of Fish and Game "species of special concern" and a Bureau of Land Management (BLM)-designated "sensitive species." *U. scoparia* habitat includes sand dunes, sand sheets, and wind dominated transitional sand-vegetation areas in the California Mojave Desert. The United States Marine Corps, Natural Resources and Environmental Affairs Division funded a multi-season project to assess population density, distribution and habitat use by *U. scoparia* on lands managed by the Marine Corps as well as nearby lands administered by the BLM. The primary purpose of this study was to begin the collection of data which would conceivably be utilized in any future discussions of Endangered Species Act listing and/or Critical Habitat designations.

Within this geographic region the Marine Corps Air Ground Combat Center (MCAGCC) at Twentynine Palms, adjacent BLM, and privately owned lands each harbor *U. scoparia* populations. While there have been limited quantitative analyses describing life history and status at individual or population levels on these lands, *Uma* populations are thought to be decreasing. In the wake of these declines and given projected increases in human population for the California Mojave Desert, both MCAGCC and the BLM have expressed concern for the future of *U. scoparia* populations on their lands. These concerns stem from certain land use practices and other anthropogenic factors which may contribute to population declines, range limitations, habitat fragmentation, and/or other factors that make all *Uma* vulnerable to extinction or extirpation. In the Mojave, military installations are bearing an increased burden of managing biodiversity. There is cause for further concern by MCAGCC with development pressure adjacent to the installation. If private land habitat for *U. scoparia* is developed and other public lands are not managed for this and other species, the sole responsibility for stewardship could fall on military installations.

The research presented here is a proactive measure to collect baseline data on *Uma scoparia* in an effort to reduce the possibility that MCAGCC will become sole steward of this species and to contribute towards preventing additional listing of this species within its California Mojave range. As such, intensive field surveys were conducted during the summer and fall of 2001 on MCAGCC and BLM lands. The purpose was to identify locations of *U. scoparia* populations and to quantify their habitat requirements. Seventy-three plots in fifteen training areas and seventeen plots in five BLM areas were surveyed. *U. scoparia* were identified in seven training areas and were identified in three BLM areas. Results from this work were in agreement with previous results for *Uma*, identifying soft sand as a major habitat component, although it was also found that *U. scoparia* will tolerate small percentages of gravel, cobble, or stones intermixed. The presence of perennial vegetation did not affect presence/absence of lizards but the presence of annuals (exotic plant species) was a negative factor to *U. scoparia*. Both MCAGCC and BLM were found to have good habitat for this species. Populations on both lands appear to be reproducing, evidenced by the number of juveniles identified during the fall 2001 field season. What remains unknown at this time is the fitness of these populations, where juveniles are dispersing, and information about the genetic structure and interaction of these metapopulations.

Recommendations were made to encourage active management with possible protection of one BLM area that harbors a large number of *U. scoparia* and to monitor two other BLM sites that also have these lizards. Recommendations were made for protecting select areas on MCAGCC. These recommendations vary with training intensity and extent of habitat. Some areas contained large amounts of habitat and received heavy use while other areas had extremely remote habitat and received low levels of use. These factors were taken into consideration when formulating recommendations. Finally, additional research was suggested. Many of these suggestions related to increasing understanding of the status of now-known populations and the genetic diversity of metapopulations in the Twentynine Palms area. Results from this type of work can be integrated with ongoing research Mojave-wide.

INTRODUCTION

Fringe-toed lizards (*Uma* spp.) are characterized by the presence of fringes of elongate spines on digits and by an ocellated dorsal pattern (Heifetz, 1941). Typical of sand burrowing animals they have a flattened body and smooth skin. The range of *Uma* includes aeolian supplied features in the southwestern US and south into northern Mexico. Because they are restricted to loose sand deposits, distribution in this range is discontinuous. Three species of *Uma* are recognized in the American Southwest and all have numerous highly specialized structural and functional adaptations that allow them to survive arenicolous habitat. The most notable adaptation is the presence of valvular scales, or fringes, on certain toes that allow the lizards to locomote on and under the sand. Enlarged scales that cover the ear openings, the eyelids, and valves that close the nasal openings facilitate subterrestrial locomotion. Being heliothermic, *Uma* lizards may also modify temperature with behavioral means (Mayhew, 1966). *Uma scoparia* is found in the Mojave Desert of California, *Uma inornata* is found directly to the south in the Coachella Valley of California, and *Uma notata* is found in the Colorado Desert south of the Salton Sea and also into the west coast of Sonora, Mexico (Stebbins, 1944).

The Mojave Fringe-toed lizard, *Uma scoparia* (Figure 1) is a California Department of Fish and Game (CDFG) species of special concern and a Bureau of Land Management (BLM) designated sensitive species. *Uma scoparia* habitat includes sand dunes, sand sheets, and wind dominated transitional sand-vegetation areas in the California Mojave Desert. Within this geographic region the Marine Corps Air Ground Combat Center (MCAGCC) at Twentynine Palms, BLM managed, and privately owned lands each harbor *U. scoparia* populations. While there have been limited quantitative analyses describing *U. scoparia* life history and status at individual or population levels on these lands, populations are thought to be decreasing.

Figure 1. *Uma scoparia* in breeding colors on MCAGCC Emerson Lake Range Training Area.

Uma scoparia are closely related to the *notata* group. They have a ventrolateral blotch and a dorsal ocelli pattern that is not linear in adults. The gular fold can have one to three black crescents and one to three diagonal black lines, unfused at the throat, running medioposteriorly and anterior to the gular crescents. One to five black shoulder blotches may be prominent and these may have an imprecise edge of yellow or greenish scales. Some individuals exhibit precloacal or lateral cloacal black spots and only a few may have post-femoral bars or spots. As do all *Uma*, *U. scoparia* posess fringes on the posterior edge of the fourth toe of the hind foot, averaging about 32 fringes. As adults males range between 70-116mm and females range 65-88mm snout-vent length. Males and females exhibit sexual pattern dimorphism of the dorsal ocelli. Both sexes present ephemeral breeding coloration (Norris, 1958). *U. scoparia* are almost wholly insectivorous. Natural predators include badgers, snakes, hawks, shrikes, roadrunners and coyotes (Stebbins, 1944).

The United States Marine Corps, Natural Resources and Environmental Affairs Division (NREA) funded a multi-season project to assess population density, distribution and habitat use by *Uma scoparia* on lands managed by the Marine Corps as well as nearby lands administered by the BLM. The primary purpose of this study was to begin the collection of data which would conceivably be utilized in any future discussions of Endangered Species Act (ESA) listing and/or Critical Habitat designations.

Habitat

Deserts are harsh environments but fringe-toed lizards have been successful in their niche within sand dunes. Morphological and behavioral adaptations allow these lizards to survive extreme temperatures and arid habitat. Although *Uma* is the only diurnal lizard species in North America that occurs in dunes with no vegetation, they do occur where vegetation is present and in the Mojave, that vegetation is typically *Larrea tridentata* or creosote bush. In the California Mojave, winter temperatures average between 4-19°C and summer temperatures average between 27-29°C. Temperatures at MCAGCC regularly exceed these desert-wide extremes. Mean annual rainfall is 102mm. Mojave fringe-toed lizards are known to hibernate from November to February (Mayhew, 1966).

The California Natural Diversity Database (CNDDB) lists *U. scoparia* as both potentially rare and having a potentially restricted range of distribution. The California Department of Fish and Game (CDFG) and the Bureau of Land Management (BLM) list *U. scoparia* as a species of special concern. The two other fringe-toed lizard species in the American Southwest, *Uma inornata* and *Uma notata notata*, both retain some form of listing as well. *Uma inornata*, the Coachella Valley fringe-toed lizard is Federally-listed threatened and California state-listed endangered species. *Uma notata notata*, the Colorado Desert fringe-toed lizard, is a CDFG and BLM species of special concern. All fringe-toed lizards have similar habitat and physiological requirements, exploit specific desert niches, are narrowly distributed within their limited ranges, and are especially vulnerable to off-road vehicle use and human development (Turner et al. 1997). *Uma scoparia's* closest geographic neighbor, the Coachella Valley fringe-toed lizard (*U. inornata*) has lost an estimated 84% of its historical habitat (~171000 acres to 27206 acres) to human development and encroachment (Coachella Valley Association of Governments, 2002), thus placing the species on the brink

of extinction. In the wake of *U. inornata* rapid declines and habitat loss, in conjunction with projected increases in human population for the California Mojave Desert, both MCAGCC and the BLM have expressed concern for the future of *U. scoparia* populations on their lands. These concerns stem from certain land use practices and other anthropogenic factors which may contribute to population declines, range limitations, habitat fragmentation, and/or other factors that make all *Uma* vulnerable to extinction. Many of the conditions that have contributed to declines in *U. inornata* and *U. n. notata* populations exist or occur within the range limits of *U. scoparia*. As a result, *U. scoparia* may suffer the same fate of its sister taxa if steps are not taken to identify populations, characterize habitat requirements, and establish management objectives that mitigate these adverse conditions. For the purposes of this report *U. scoparia* will hereafter be referred to simply as *Uma*.

Problem Statement

While individual research efforts have examined each of the three fringe-toed lizard species throughout Southwest (Durtsche, 1992; Pough, 1970; Mayhew, 1966), these studies have focused primarily on ethology and on other characteristics at an individual level rather than at the population level. No study has yet empirically derived a predictive habitat model for *Uma* distribution or estimated abundance; nor has previous research examined the unique challenges for environmental stewardship of biodiversity faced by the Department of Defense (DoD) in the California Mojave Desert. The greatest challenge faced by military installations is the threat of encroachment by civilian development. As private lands are developed, suitable habitat for many Mojave Desert species is lost. These animals are either extirpated if unable to reach suitable habitat or if unable to relocate to undeveloped areas. With the development of private lands in the California Mojave, a greater percentage of undeveloped land is managed by either the US Department of the Interior (DOI) or DoD. As a result DOI and DoD both bear an increasing burden of sole stewardship of biological diversity. There is cause for further concern by DoD, however, with increasing development on private lands. This concern is simply the following: If habitat for biodiversity is developed on private lands and DOI lands are not managed for biodiversity, *the sole responsibility for stewardship of biodiversity may, as a result fall on military installations*. Nationwide, this scenario of sole stewardship by DoD already exists at various stages, evidenced by the fact that of all federally managed lands, the DoD harbors the greatest percentage of federally listed threatened and endangered species (TES) both in total numbers and per managed acre (Groves et al., 2000).

The difficulty of having sole stewardship of biodiversity, particularly for TES, is the potential conflict with the military mission. DoD lands are charged with military readiness for National Security and each installation serves a unique purpose in defense preparedness. However, as Federal land managers, DoD must also comply with the Sikes Act and the Endangered Species Act, both of which require adequate knowledge of the numbers and locales of threatened and endangered species within installation boundaries. Until the 1990's, DoD operated in a reactive mode with respect to fulfilling the requirements of the ESA. That is, resources were not allocated towards a TES species until it became Federally listed and/or interfered with the military mission.

Previous *Uma scoparia* research on MCAGCC

Fromer and Dodero (1982) conducted a reptile survey on MCAGCC between October 26, 1981 and June 15, 1982. The purpose of this survey was to collect baseline data on the occurrence and distribution of reptiles on the base. *Uma* was found to occur and be restricted to areas of fine, windblown sand. Three populations were identified on MCAGCC at North Sand Hill, Emerson Lake, and Pisgah Lava Flow, the latter of which technically is not within military boundaries. Fromer and Dodero (1982) hypothesized that other populations within MCAGCC likely existed, suggesting Surprise Spring and Mainside areas as likely areas to support *Uma*.

A year later Fromer, *et al.* (1983) conducted a population study of *Uma* on MCAGCC. This work was restricted to the populations identified in the 1982 study, above. All lizard species observed were recorded and some discussion of lizard community structure was presented. *Uma* densities were reported between 5.3 and 12.5 animals per hectare. An uneven sex distribution, 20:9 females to males, was found among the animals captured. Based on this work, the authors suggested that training activities on MCAGCC did not significantly affect existing *Uma* populations. At the same time, a recommendation was made that no long term, high intensity, localized activities be conducted on existing habitat areas. Specifically, this referred to construction of permanent structures or activities that resulted in devegetation.

More than a decade later, Cutler *et al.* (1999) found *Uma* in sand dunes within Quackenbush, Lead Mountain, Acorn, and Lavic Lake Range Training Areas (RTAs). They reported that other researchers found *Uma* within Emerson Lake and Sand Hill RTAs, but did not specify whom. It is likely that this reference was to the earlier work of Fromer and Dodero (1982). Cutler *et al.* recommended that efforts focus on locating all populations and determining the extent of their range on MCAGCC.

LizLand

In order to assess and qualitatively predict *Uma* habitat within MCAGCC, we employed the use of the spatially explicit habitat model LizLand (Heaton and Keister, submitted 2001). Prior to LizLand, the existing state-of-the-art in habitat modeling in the California Mojave Desert was the combined work of the California GAP Program (Davis *et al.*, 1998) and the California Wildlife Habitat Relationships System (CWHR) (Airola, 1988). Along with distribution maps the CWHR describes the management status, life history and habitat requirements of California's wildlife species. The USGS National GAP Program (Scott *et al.*, 1993) produced species habitat maps for most mammals (except bats), birds, amphibians and reptiles across much of North America, including those found in the California Mojave Desert. Both the National GAP Program and the CWHR were built upon one of the most successful and widely used means of defining species habitat relationships: the categorization of the landscape into land cover classes based on vegetation composition. The science of wildlife-habitat relationships was developed and continues with birds as model species and vegetation as the habitat predictor (Merriam, 1890; Adams, 1908; Lack, 1933; Svardson, 1949; Hilden, 1965; Verner *et al.*, 1986; McCullough & Barrett, 1992; Scott *et al.*, 1993; Morrison *et al.*, 1998; Scott *et al.*, 2002). The concept of habitat has expanded considerably

over the years to include not only environmental structure, but also inter- and intra-specific competition, presence/absence of conspecifics, predators, spatial and temporal climatic variables, evolutionary history and many other factors. However, vegetation, because of historical usage and universal availability, remains the primary variable used to predict animal presence/ absence.

GAP is a biodiversity assessment and inventory tool that employs a "coarse" vegetation filter of community inventory and protection (Davis *et al.*, 1998). This "coarse" filter method is hypothesized to protect 85-90% of the species, leaving the remaining 10-15% for "fine" filter approaches (Jenkins, 1985; Noss, 1987). Because vegetation is sparse to non-existent across much of the California Mojave Desert, we suggest that the "coarse" vegetation filter approach employed by GAP is also likely to work in only a portion of the total number of ecosystems. A "fine" filter approach is necessary for ecosystems that are unusual, rare, or in which vegetation is sparse, such as the California Mojave Desert. California GAP does not adequately describe the habitat requirements of reptiles in the California Mojave Desert because it relies on vegetation and ignores geomorphic patterns/processes as habitat descriptors, and because it does not address the disparity between the scale of research used to study reptiles, or more importantly, the scale at which reptiles perceive/respond to the environment.

Conceptually, LizLand is centered on geomorphic landforms, but also considers the contribution of vegetation composition and structure to habitat requirements at a species level. To date, an appropriately scaled, reliable, accurate, and consistent spatial representation of vegetation across the entire Mojave Desert does not exist. As a result, the LizLand GIS model is based solely upon the characterization of the macro landform and its link to lizard habitat. However, due to the limited habitat requirements, and the patchy distribution of those features, the identification of geomorphic sand dunes and sand sheets remains an adequate method for locating habitat for all *Uma* species. By focusing the characterization of habitat on geomorphic landforms rather than vegetation, the unique biological requirements of *Uma* species desert reptiles are addressed. By linking large-scale macro landforms to lizard habitat via micro landform characterizations, the issue of management scale and ecosystem research is addressed as discussed by Heaton & Keister (submitted 2001).

Military installations, like deserts, are not the vast, homogeneous, single land use entities as perceived by the public. They often have highly complex and heterogeneous assemblages of landforms along with associated vegetation types. Large installations may have dozens of separate habitat types that, individually, or together support numerous animal species. While many of these species occur over large areas and in abundant numbers, others are rare, threatened or endangered. Too often this rarity is due to land use practices outside the boundaries of the installations that diminish or eliminate habitat. As external pressures continue, the military is now finding its officials have also become managers of wildlife refuges to some extent, rather than or in addition to being providers of training and testing facilities for national security. As a result, the military must make use of existing information such as wildlife habitat relationships, or develop its own data, to identify those sites which may need further protection or study.

If the data on species are minimal or the "coarse" filter approach inadequately protects a given species or fails to capture the unique complexity of the at-risk ecosystem, the result can lead to inaccurate perceptions of the amount of associated habitat on the installation. The result might be pressure to set aside more land than is warranted, thus unnecessarily removing it from training and testing, or the military might find itself inadvertently disturbing land which in fact harbors the very species they are trying to protect. More detailed information provides the military, as well as other interested stakeholders, with a better and more accurate picture of the value of land from a habitat perspective. In this position, the military, as well as other federal agencies, are better able to negotiate, and potentially mitigate, issues related to biodiversity with surrounding stakeholders, all of whom must comply with local, state and federal laws related to rare, sensitive, threatened or endangered species and associated habitat.

OBJECTIVES

MCAGCC employed a proactive approach with the Mojave Fringe-toed lizard in an effort to build and employ a collaborate effort among federal land managers to maintain population viability and to potentially prevent Federal listing of *Uma*. MCAGCC spearheaded and funded this effort to investigate *Uma* within MCAGCC boundaries and on adjacent BLM land. By including data beyond its political boundaries, MCAGCC has sought to accomplish the following: 1) collect critical baseline information on *Uma* at individual *and* population levels, 2) determine the similarities and differences in distribution of *Uma* on both MCAGCC, adjacent BLM, and potentially some private lands, and 3) create an empirical habitat relationship model for *Uma* in designated focal areas. The results of this research will contribute to efforts towards reducing or potentially eliminating the risk of Federal listing of *Uma*. If *Uma* were to be Federally listed as threatened or endangered, aspects of MCAGCC daily operations might face major alterations, potentially resulting in elimination of operations. MCAGCC is taking a proactive stance by collaborating with BLM to better understand the habitat requirements and distributions of *Uma* thus reducing its chances of following the same trajectory as other *Uma* species in the desert Southwest.

We evaluated habitat and population location parameters for *Uma* within designated MCAGCC training areas and surrounding BLM lands and to create an empirically based habitat suitability model based on these data. The terrain based lizard habitat model, LizLand, successfully developed on MCAGCC and Joshua Tree National Park for other Mojave Desert lizard species, was adapted to accommodate the specific requirements of *Uma*. LizLand is a spatially explicit, landform based habitat model that links the requirements for individual and population distributions of lizards with geomorphological landscape characteristics.

We addressed the following objectives:

1. Develop a predictive model of *Uma* habitat on MCAGCC and adjacent BLM lands based upon landform characteristics.

2. Determine presence/absence (p/a).

3. Describe and compare the physical characteristics of those areas where *Uma* does and does not occur.

4. Provide management recommendations to MCAGCC and BLM.

STUDY AREA

The study area for this research is MCAGCC and a limited extent of adjacent BLM lands (Figure 2). Proposed study sites included the following MCAGCC Training Areas (RTAs): Acorn, East, Emerson Lake, Gypsum Ridge, Lavic Lake, Lead Mountain, Maumee Mine, Prospect, Quackenbush, and West. Because MCAGCC lands are used for active testing and training exercises that may pose safety threats to civilians, access is both restricted and limited. BLM managed study sites included areas to the north of MCAGCC, particularly the Sunshine Peak-Pisgah Lave Flow, and the western and the southeastern boundaries of MCAGCC. All BLM sites were to be within close proximity to MCAGCC boundaries and no farther than 15km from the nearest MCAGCC border point. The study area included MCAGCC and a buffer strip of BLM land between 0 and 15 km from the installation boundaries.

METHODS

Sample points were randomly generated for a total of 87 potential dunes to be sampled. The number of sample points was generated based on sample size estimates of (Get Ref: Surveying Sample Size) where $n = Z^2 * var/[(\%)(mean)]^2$. The Z-value of 1.96 was based on a 0.95 confidence level and "%" is desired tolerance ± the mean density. The desired tolerance was set to 25% and mean density was based on estimates from previous research on MCAGCC FTL of Fromer and Cutler *et al.* (1999). Based on these calculations, a minimum of 80 sample points were required to achieve estimates between ±25-30% of the true mean estimates. Within each sample dune (location), a 0.5 ha sample plot was randomly generated. The order each site was visited was also randomized and was accommodated as well as could be scheduled in accordance with MCAGCC Range. Rules for determining the number of sample sites with a selected dune were:

- Dunes < $2km^2$ get maximum of 1 sample site
- Dunes > $2km^2$ but < $4km^2$ get maximum of 2 sample sites
- Dunes between 4-$6km^2$ maximum of 3 sites
- $6km^2$ maximum five sites
- The large sandsheet within Range Range Training Area was not sampled due to safety issues

Locations of sample sites were generated using a random-stratified sampling regime. Dune features including sand sheets were delineated from 1m true color DOQs for the Marine Corps Base at Twentynine Palms. A total of 59 dune and sand sheet features were identified based in part on interpretation of the DOQs and validated by ground truth collected while

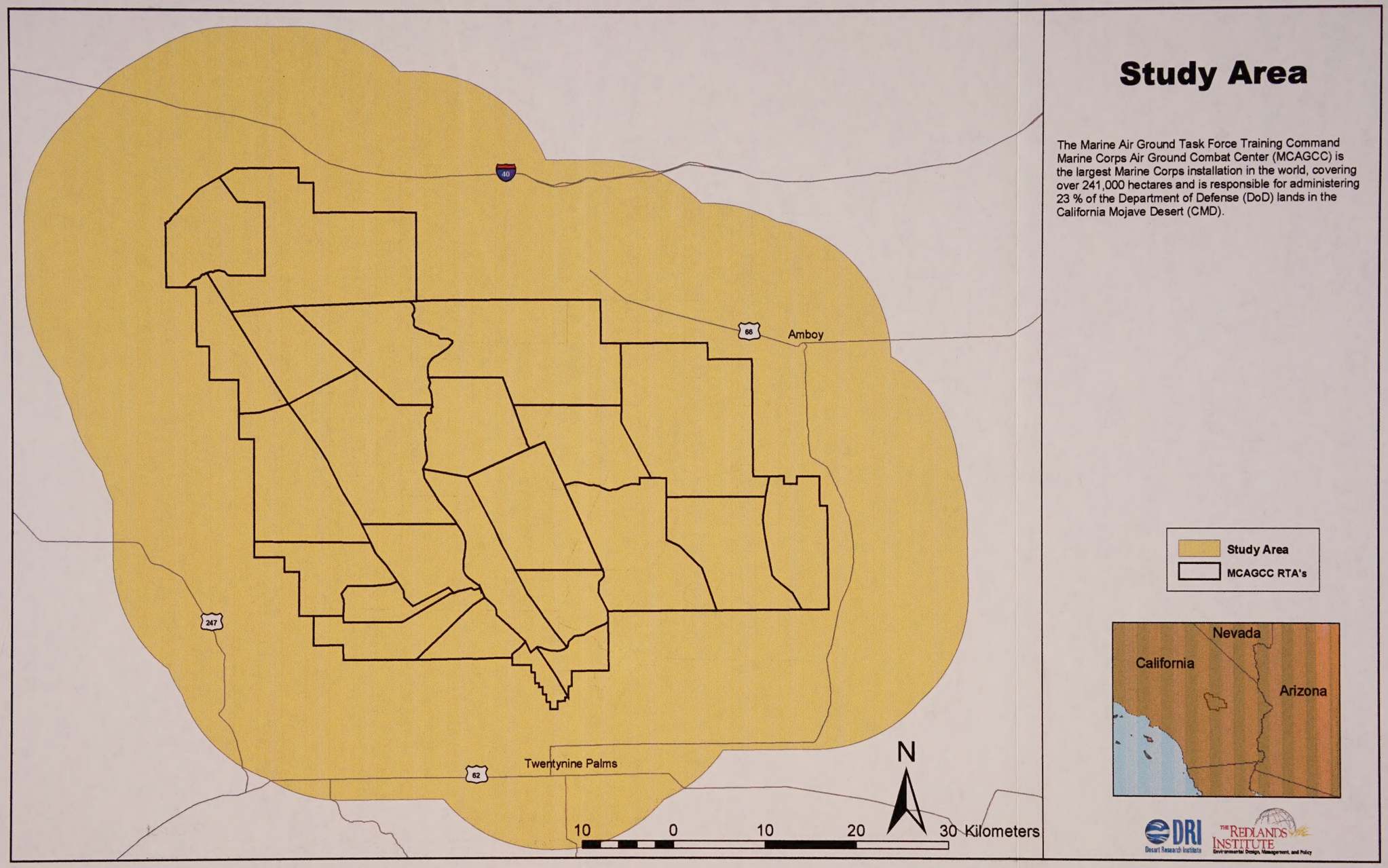
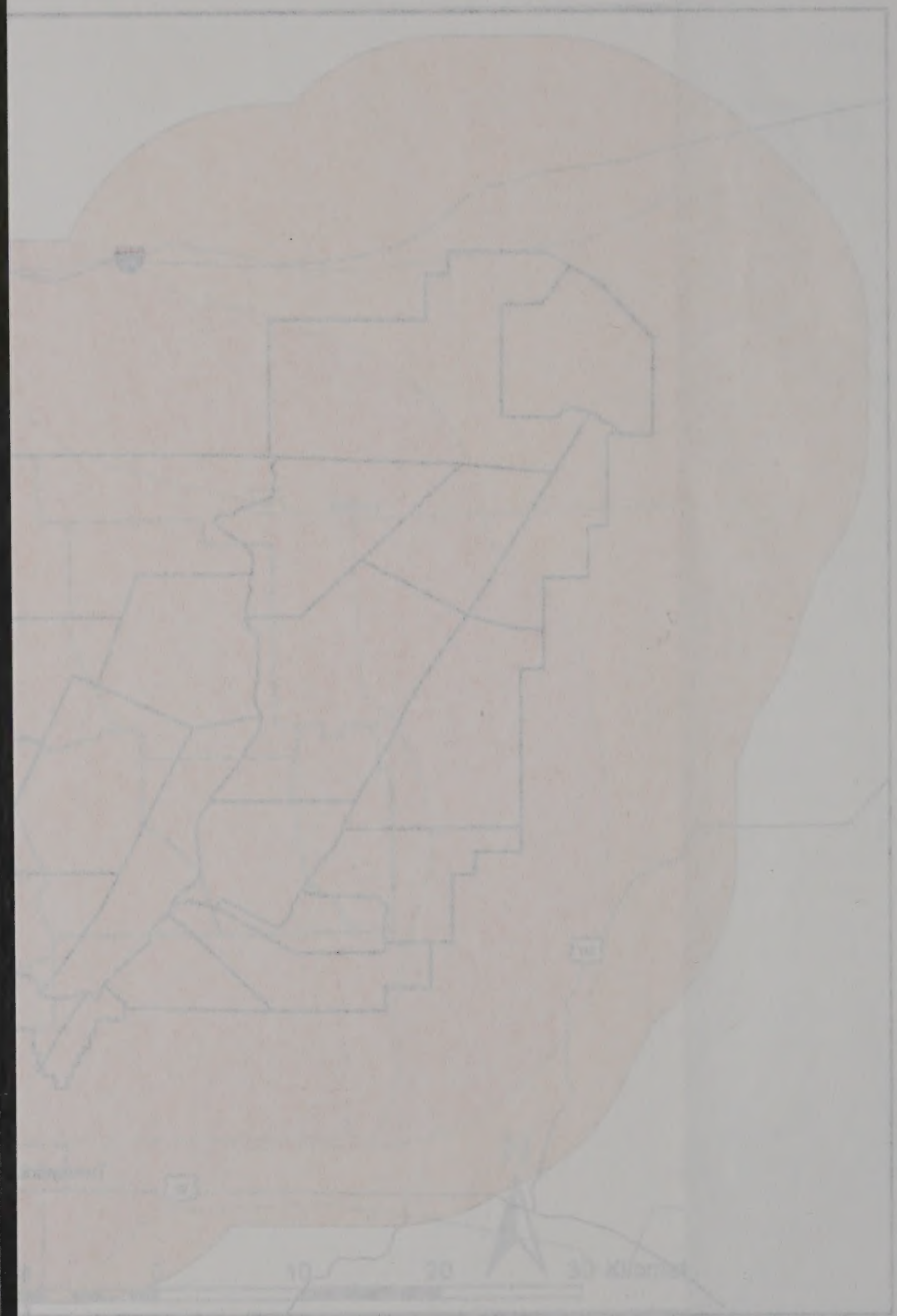

Study Area
The Marine Air Ground Task Force Training Command Marine Corps Air Ground Combat Center (MCAGCC) is the largest Marine Corps installation in the world, covering over 241,000 hectares and is responsible for administering 23 % of the Department of Defense (DoD) lands in the California Mojave Desert (CMD).
40
66
Amboy
247
62
Twentynine Palms
N
10 0 10 20 30 Kilometers
Study Area
MCAGCC RTA's
Nevada
California
Arizona
DRI
Desert Research Institute
THE REDLANDS INSTITUTE

Figure 2. Study area including 15km buffer to include adjacent BLM managed land.



visiting MCAGCC in October 2000. Sample points were generated randomly within each dune and sand sheet. A total of 124 possible sample points were generated on MCAGCC and 22 points were generated for adjacent BLM land. Using data collected by Cutler *et al.* (1999) and Fromer *et al.* (1983) on MCAGCC we estimated that a sample size between 65-93 would need to be taken in order to achieve 75% to 85% confidence intervals around our estimate of lizard density. This is well within the expected confidence limits for this type of fieldwork (Hayek and Buzas 1997). Of the complete set of 124 MCAGCC and 22 BLM potential sample sites, 87 points on MCAGCC and 10 points on BLM lands were randomly selected and surveyed.

After the first field season it became apparent that the dune features identified from the DOQs did not effectively capture potential *Uma* habitat. The reason for this lies in the physical properties of sand as a substrate and its reflective properties in the visible portion of the spectrum. Recall that the DOQs were photographs taken in the visible wavelengths of the spectrum. Compacted sand "looks" like soft sand. Color differentiation between soft, unconsolidated sand features, cemented, hard sand surfaces, and cemented, hard clay surfaces is virtually impossible. As an example, there appears to be soft sand present within and next to the lava fields in Lavic Lake. Ground truth revealed this sand to be a mini playa, compact and solid-surfaced. Spectrally, these would-be dune features appear identical to other features, such as those found to be actual soft dunes on Prospect or Emerson. Likewise areas that, based on ground knowledge, were known not to be unconsolidated sand, appeared spectrally similar to true dunes or sand sheets. Investigation of the Dokka data, a geomorphological coverage generated at 30m spatial scale Mojave-wide, did not offer additional features because only one sand sheet was identified to exist on MCAGCC (which was delineated also with DOQs). Shape and texture are the other elements used to identify and delineate features from a DOQ. A star dune was identified in Maumee Mine, although ground truth revealed it was ancient and had long ceased to function as a dune. The substrate surface was compact and was primarily large cobbles. It was also heavily vegetated.

In the process of sampling, features identified as dunes on the DOQs, both errors of omission and commission were found to occur. These two error types are standard in any ecological survey, particularly in the use of remote sensing data, and are unavoidable. Research cannot be one hundred percent accurate despite best efforts. For reasons explained above, dunes and sand sheets were located on the ground that were not identified in the DOQs (error of omission). Areas that appeared to be sand dune features or sand sheets in the DOQs were not features of this type on the ground (error of commission). For this reason the sampling design was amended to maximize sampling in suitable habitat and to better delineate suitable habitat on MCAGCC. The original protocol was amended to maximize *Uma* sightings and data collection. The protocol for the fall field season was expanded to locate sample points based on two criteria: 1) identification of potentially suitable habitat in the form of a sand dune, sand sheet, or other loose sand area; and 2) identification of *Uma* while driving or walking. The original protocol used only the DOQ-generated dune features and was designed to evaluate differences in habitat at the plot level where *Uma* do and do not occur. The data collected in the first field season support a complete research study designed to address

questions relating to *Uma* habitat based on data that characterize where these lizards are and are not found.

In the amended protocol, the field crew spent time searching for potential habitat in as many training areas as possible. Time spent searching (i.e. driving and hiking) was proportional to the relative area of the training area and estimates of potentially suitable habitat. In other words, training areas that were primarily mountainous but of relatively large size, such as Cleghorn Pass, had less intensive efforts spent searching than Lead Mountain or Lavic Lake. This revised method also served to better delineate dune and loose sand habitat throughout MCAGCC.

Under the amended protocol, the crew drove appropriate roads, which did not include washes or unofficial travel routes. When potential habitat was sighted they hiked to that location and digitized the boundaries, if possible, or approximate center point coordinates if delineating the entire perimeter was not possible. Delineating the entire perimeter was not necessarily possible due to size and time constraints or due to 'fuzzy' boundaries of the dune feature. Using random selection techniques within each dune feature, a plot was delineated and data collected in the exact manner as was done for the summer fieldwork. The same data were collected in plots during each field season. Plots of 0.5 ha were delineated and walked using constrained area search techniques. Start and stop times and temperatures were recorded, respectively. Percent cover of particle size and vegetation were assessed. All other vertebrate species encountered were recorded.

To summarize, as a result of the limitations of using DOQs to delineate suitable FTL habitat two protocols were employed that maximized data collection on FTL habitat on MCAGCC. The first field season was devoted to a statistically designed random-stratified plot survey protocol based on *a priori* habitat assumptions. The analyses of these data yielded information about *Uma* habitat at a plot level. These plots were completed before the amended protocol was implemented. The second field season was used to continue data collection to add to the database on FTL locations but was designed to maximize ground observation based sampling. Data from the amended protocol were analyzed to compare differences in *Uma* observations, primarily between adults and juveniles. The amended protocol was exploratory in that it served to expand the existing database on recorded *Uma* observations. The net result of both field seasons was a more thorough and complete sampling of both MCAGCC and BLM.

Data collection

For each survey plot, the date and the location were recorded in UTM zone 11, NAD 83. Each survey plot was given a survey plot ID consisting of a training area abbreviation and a number. The number was either previously assigned, as in the summer field season protocol, or for fall season designated by increasing sequential numbers. BLM plots started at 101, and used the abbreviation of "blm" (e.g. BLM101). MCAGCC plots started at 200 and used abbreviations of the training areas (e.g. EL200 for Emerson Lake). Plot locations were not pre-assigned in the fall season because the survey points were not generated *a priori.*

The start time for each plot was recorded as the time at which data collection began, or the time at which the first *Uma* was seen when using the fall protocol. At this time air and surface temperatures were taken. Ambient air temperature was recorded at chest height in the shade 4-6 inches out from the body. Surface temperature was recorded in the shade (body shadow) on the ground, with the thermometer tip in contact with sand, but not covered by it. Subsurface temperature was taken with the probe inserted approximately four centimeters into the sand. The end time reflects the time at which transects were completed. Air and surface temperatures at end time were also recorded. Wind bearing and speed was recorded at the beginning of the survey. If it was not windy at the beginning of the survey, but developed and existed for the majority of the plot, the wind reading was taken at the finish time. The field crew also took note of cloud cover and recorded when the last known rain in the area had occurred based on their field notations. Because rainfall is spotty in both time and location in deserts, particularly in the Mojave, standardized weather or climate data were not used to populate this field. This particular field of information in the database was collected for future reference purposes only.

In each plot, the general condition of the area was recorded as climbing/falling dune, a sand sheet, or hummock habitat. In addition, the field crew noted if the sand was loose wind blown, soft-medium, or hard packed; and the presence of Mediterranean grass, Russian Thistle, Saharan Mustard, tire tracks, trash, foot traffic or any other unusual physical characteristics.

Using random sample plots within each dune sample location the percent cover of perennial and annual vegetation, as well as the substrate composition (particle size distribution) was estimated. Substrate composition was broken into four categories as listed in Table 1.

Table 1. Particle size class recorded for each plot.

Sand	<5 mm
gravel	5-75 mm
cobble	75-250 mm
boulder	>250mm

Summer field season

A stratified random sample design was developed based on sample size calculations as described above (see METHODS). Surveys serve to sample populations because we cannot count every individual within a population. Sampling is a means to make estimates about the population. It is important to note that while different means of sampling yield data that may or may not be comparable with similar statistical tests, there are a number of statistical tests that can be applied to the same data set. In this research, therefore, different statistical tests were applied to data collected in the same manner at the same time. The reason for this is that the inherent data properties, such as distribution, vary significantly. There are different tests for data that are normally distributed than for data that have non-normal distributions. Without an evaluation of the sampled data, statistical results may be invalid as assumptions are violated.

The stratified random sample design is a form of probability-based sampling and serves to maintain the independence of the sampled data points but also allows incorporation of *a priori* knowledge-based sampling. In the instance of *Uma scoparia*, it is known that the lizards occur in sandy substrate typically in the form of sand dunes, sand sheets, or other windblown (aeolian) sand features. They are not known to occur in lava, rocky surfaces, cliff faces, mountainous areas, or on paved surfaces. Looking for these animals in these locations will certainly yield negative results; they will not be found to occur there. There is a gradation in suitable habitat where they may be found, however, and evaluating this gradation is a part of the research question. These lizards do occur where vegetation exists, but the question remains as to how much vegetation is acceptable. There are other levels of detail to be investigated such as what kind of vegetation is tolerable – annuals, perennial shrubs or both? How much of these vegetation types is tolerable? From an abiotic habitat perspective there are also questions to be addressed such as what proportion of sand is tolerable to these lizards? Must an area be comprised entirely of loose, windblown sand or do these lizards occur where there is a mix of substrate sizes? If there is a mix, what size classes and associated proportional amounts are acceptable? These refined habitat questions can be addressed only with an experimental sample design. The sample design allows us to better refine our understanding of habitat preferences of *Uma scoparia* rather than simply surveying for presence.

The first step of the stratified random design is the "stratified" portion. This means that we refined our sampling to areas where *Uma* should occur, but did not restrict the sampling to what would be considered, based on existing literature, excellent habitat. Interpretation of the digital orthophotographs (DOQs) for dune features identified the features within which sampling would occur. Features that did not appear to be comprised of loose sand such as lava or desert pavement were not sampled.

The second part of the stratified random sample was the random selection of plots within dune features identified as described above, to be surveyed. Statistically, plots are selected randomly to maintain independence and minimize bias. Because we had a variety of sizes of dune features and a wide range of dune feature frequency among training areas, the actual number of random samples per training area were weighted by amount of dune surface. In other words, training areas with a large area coverage of dunes received more random sample plots than a training area with less total area coverage of dunes. This process focused sample efforts to locations where *Uma* were expected to occur while allowing for statistical tests to be run on the data. Without the stratified random sample, no valid statements could be made about the differences in habitat where *Uma* did or did not occur.

The sample design was created to maximize identification of *Uma* habitat as evidenced by the occurrence of individual animals. Survey plots were sampled regardless of appearance on the ground because the objective was to quantify habitat characteristics of *Uma* on MCAGCC. To make valid statements about where individuals do occur, it is necessary to compare against where they do not occur. As an example, if *Uma* were found in areas that contained 97-100% sand, it would not be valid to say that any area with 97-100% sand is *Uma* habitat because we cannot say that they *do not* occur under the same conditions. If however, it was found that *Uma* occurred in areas with 87-100% sand but individuals were at

the same time found *not* to occur in areas with 0-95% sand, we could test for statistical significance between the sampled areas and make conclusions about percentage of sand as an indicator of habitat suitability. Without data on both where individuals occur and where they do not occur, no conclusions about the measured variable can be drawn with the exception of measured range of the data set.

The protocol for the summer field season was as follows. The field crew navigated to each of the selected locations using Global Positioning System (GPS) technology. The GPS coordinate was used as the center of the first 0.5 ha plot (70x70m). On rare occasions the survey plot was altered from the designated coordinates and size because the actual dune was significantly less than 0.5 hectare and/or bordered by boulders. Survey plots were only completed when the air temperature was between 29 and 40 degrees Celsius and this range was based on published literature. Plot boundaries were delineated and data were collected within each plot with no time limit. The 0.5 ha plot was walked in repeated linear non-overlapping transects to identify any *Uma*. Transects were approximately 5 meters apart, parallel with one of the survey plot borders. When a lizard or other reptilian species was sighted in the survey plot, the location of the lizard was recorded with the GPS. If the lizard was an *Uma* the air, surface, and sub-surface temperatures were recorded and a soil sample was taken. Other characteristics of the original location of the *Uma* were recorded (i.e.- open/shade, sun/perennial/annual). The field crew also recorded any significant behavior. Once the survey plot was completed, the field crew took final air and surface temperatures and recorded the finish time. Start and stop time, ambient air, surface and subsurface temperatures, wind speed, vegetation cover and substrate composition were recorded at all plots. Other species, such as desert tortoises, were noted and locations taken with the GPS. The last known rain, cloud cover, and any other notable topographic features were also documented.

All but 12 plots were sampled in the summer field season. These remaining 12 plots were visited during the fall field season, completing the stratified random sampling survey. Only after these 12 plots had been completed did the ground-based survey protocol begin.

Fall field season

The field crew drove throughout the designated training areas on MCAGCC or through BLM land looking for suitable *Uma* habitat. Suitability was determined by the presence of large patches or continuous loose to medium packed non-granular sand. The field crew often looked in areas of hard packed sand, Mediterranean grass, or otherwise marginal habitat, as it is often difficult to distinguish the quality of the habitat without walking through the area. Approximately 20 minutes was spent investigating potential habitat on foot once identified as such from the road. During this time coordinates for any reptilian species found were recorded. If suitable habitat was not found, the crew returned to their vehicle and continued driving. If suitable habitat was located, survey data were collected, in the method described above for "summer field season."

Searching for suitable habitat was done only when the temperature was above 23 degrees Celsius. If an *Uma* was seen at temperatures this low, the field crew recorded its location and all related data as described above under "summer field season". Survey plots were typically

not started until the air temperature had reached 25 degrees Celsius. The maximum ambient air temperature for conducting surveys was 40 degrees Celsius.

Once habitat was determined to be suitable, or an *Uma* was seen, a survey plot was delineated and data collected. Generally the first *Uma* became the center point for the survey plot, which was then oriented with the coordinate system. The exception to this was when *Uma* was located on the edge of the habitat, in which case the individual's location became a corner for the survey plot. This enabled the field crew to ensure that the survey plot covered the majority of the suitable habitat, and therefore gave a better assessment of the number of *Uma* in the area. If no *Uma* were seen initially, the corner of the survey plot was randomly chosen by the toss of a pin flag.

The manner in which the survey plot and sample plots were completed did not vary between the summer and fall protocols.

In the fall field season, the field crew took note of any lizard that they saw while traveling and recorded its position with GPS as well as the species name and other ancillary information. This same information was taken for reptilian species other than *Uma* that were found in survey plots. Species were noted by a four-letter designation, using the first two letters of the genus and the first two letters of the species.

Species Abbreviations

Cadr	*Callisaurus draconoides*	Zebra-tailed Lizard
Cnti	*Cnemidophorus tigris*	Western Whiptail
Cova	*Coleonyx variegateus*	Western Banded Gecko
Dido	*Dipsosaurus dorsalis*	Desert Iguana
Gasi	*Gambelia silus*	Blunt-nosed Leopard Lizard
Gawi	*Gambelia wislizenii*	Long-nosed Leopard Lizard
Goag	*Gopherus agassizii*	Desert Tortoise
Phpl	*Phrynosoma platyrhinos*	Desert Horned Lizard
Uma	*Uma scoparia*	Mojave Fringe-toed Lizard
Urgr	*Urosaurus graciosus*	Long-tailed Brush Lizard
Utst	*Uta stansburiana*	Side Blotched Lizard

Each *Uma* that was found within a survey plot was given a unique identification consisting of 'uma', the sequential number that identified that individual, and the survey plot ID. For example, the fourth *Uma* in Emerson Lake 208 was designated as: "uma04EL208". For each *Uma* found in a survey plot, time of sighting, air, surface, and sub-surface temperature were taken. The field crew also recorded if the *Uma* was seen in the open or shade, in a perennial, annual, or burrow. In the fall season a large number of juvenile *Uma* were seen, and when the field crew could determine the juvenile or adult status, it was noted.

In the fall season data was taken from the data sheets and entered into ArcView manually. A polygon theme for survey plots, a point theme for *Uma* in each survey plot and a point theme for other species seen (including other species and *Uma* seen on the way to the survey plot) were created for both BLM and MCAGCC land. A theme that identified the location of and

type of other reptiles that were found was also created. Data was entered within one week of visiting each plot to help ensure accuracy, and was double-checked for quality control at the end of the field season. The themes were then merged with the summer season once all the data had been collected and entered for the fall. One file with all *Uma* data was then created from all files.

MCAGCC Training Areas

The field crews sampled fifteen of the twenty-four training areas on MCAGCC between June and November 2001 (Table 2). These training areas were sampled for a total of 27 days in the summer field season and 22 days in the fall season.

Table 2. Number of plots and days spent in each MCAGCC Range Training Area.

MCAGCC	Summer Plots	Fall Plots	Total Number of Plots		Number of Days Summer	Number of Days Fall	Total Number of Days
Acorn	6	1	7		3	1	4
Bullion	0	0	0		0	1	1
Cleghorn Pass	0	0	0		0	1	1
Delta	0	0	0		0	1	1
East	2	0	2		2	0	2
Emerson	16	2	18		4	6	10
Gays Pass	0	0	0		0	1	1
Gypsum Ridge	4	4	8		2	2	4
Lavic Lake	8	0	8		4	1	5
Lead Mountain	4	2	6		2	2	4
Mainside	6	0	6		2	2	4
Maumee Mine	4	0	4		1	1	2
Prospect	4	2	6		3	2	5
Quackenbush	4	0	4		2	1	3
Tortoise	4	0	4		2	0	2
Total	62	11	73		27	22	49

Bureau of Land Management Areas

DOQs were not available for BLM land within the 15km buffer of MCAGCC. Although the DOQs for MCAGCC did extend beyond the installation boundary, the additional coverage was not extensive and no dune features were identified within the area covered by the MCAGCC DOQs. Dune features to sample were identified based on knowledge of the area from multiple sources, including NREA officials, BLM officials, and researchers personal knowledge of the areas. The stratified random sample approach was employed for these identified areas in the same manner as was done for MCAGCC plots.

BLM land was surveyed four days in the summer and 12 days in the fall. All the BLM lands visited in the summer had survey plots, but some of the visits in the fall were of a purely

exploratory nature and did not have survey plots, as suitable habitat was not found in these areas. To clarify, exploration on BLM land was undertaken to locate previously unknown habitat areas, particularly since adequate dune coverage did not exist for BLM land and DOQs were not available from which to derive a dune feature coverage. BLM plots and exploration occurred when scheduling did not permit surveying on MCAGCC as well as after survey plots for the entire study were completed. Exploration on BLM land in no way inhibited or reduced the amount or quality of data collected on MCAGCC. Exploration of BLM land was part of the amended protocol and was therefore run parallel and as a part of the amended fall sampling strategy. There were a total of five areas of BLM in which plots were completed in the summer and fall (Table 3):

1. Spy Mountain, west of the Acorn training area is bordered to the north and east by MCAGCC and by private land to the west and south. Sites were completed in the summer field season. Further investigation in the fall season determined that there was no suitable habitat and additional plots were not generated for this area.

2. West Mainside was visited during the summer season, and four plots were completed at predetermined locations. This area is located just west of MCAGCC. No further investigation was required in the fall field season.

3. Copper Mountain is southwest of MCAGCC. Plots were done in the fall season only. The area is surrounded by private land.

4. Valley Mountain is south of Cleghorn Pass. The western border is a combination of MCAGCC and private land, the southern border is private land, and the eastern border is the Cleghorn Wilderness. Plots were visited in the fall field season.

5. Bristol Mountain is north of Highway 40, and east of the town of Ludlow. Plots were done in the fall field season. Plot locations were believed to fall within wilderness. Two BLM access roads create the northern and southern boundaries of the dune habitat.

Table 3. Number of plots and days in each BLM study area.

BLM	Summer Plots	Summer Days		Fall Plots	Fall Days
Copper Mountain	0	0		6	6
Valley Mountain	0	0		2	2
Bristol Mountain	0	0		2	2
West Mainside	4	2		0	0
Spy Mountain	3	2		0	1
Total	7	4		10	11

Scheduling

The work was scheduled by submitting requests for access to training areas through MAGTFTC NREA. Scheduling with MAGTFTC Range Control (BEARMAT) is critical for a number of reasons. First, safety was the highest priority. Some training areas were available

for surveying at any time, as they are not used for live-fire military training. Other training areas were off limits entirely and were not sampled. The field crews and NREA were able to schedule sampling within the training areas that were indicated to have suitable FTL habitat. The days in which MCAGCC training areas were unavailable were used to survey BLM land.

Equipment

Various kinds of equipment were necessary for fieldwork. A 4X4 vehicle was required for travel throughout the installation. A Motorola cell phone with AT&T wireless services was used to communicate with BEARMAT and for emergency purposes.

A Garmin 12XL GPS receiver was used for data collection and in conjunction with topographic maps provided by MCAGTFTC for navigation. The field crew used ArcView generated maps with ownership layers created by the lab at MCAGCC to determine the extent of BLM land. In addition, a 1997 BLM Special Edition Surface Management Status Desert Access Guide was provided. The GPS was also used to navigate to the corners of the survey plots and the UTM coordinates were marked at all lizard sighting locations. All of the data was taken on field sheets, and then transferred into a laptop using ArcView version 3.2.

Statistical Analyses

Plot level analyses were conducted on the data collected at the plot level based on stratified random sampling. F-tests were run on vegetation, particle size, and temperature data to determine the appropriate comparative tests for significant difference of plots with and without *Uma.* F tests determine whether or not the variance of two samples, in this case plots with *Uma* and plots without *Uma*, are similar or not. Summary statistics were also calculated to determine distribution frequencies of the data. The Shapiro-Wilk W test, in combination with frequency histograms and normal plots were used to evaluate which habitat variables were non-normally distributed.

Based on the results of the F-tests, Shapiro-Wilk W test, frequency histograms, and normal plots, Mann Whitney U tests, also called the Wilcoxon rank-sum test, were then run to determine if there were statistically significant differences between habitat variables in plots where *Uma* were and were not found. A significance level of $\alpha = 0.05$ was used in all calculations. Mann Whitney U tests, which are non-parametric, are more appropriate than an independent samples t-test when data are non-normally distributed. Confidence intervals around the difference between medians were computed using the Hodges-Lehman method. T-tests were appropriate to compare temperature data sets as these data were normally distributed. Two-sided t-tests were run at a significance level of $\alpha = 0.05$ on temperature data.

Spearman-rank correlation was used to determine the degree of association between the number of *Uma* found in a given plot and habitat variables. This was done to determine if there were an obvious relationship between density of individuals and physical habitat. This test statistic is also non-parametric and is equivalent to ranking the observations then

analyzing the ranks using the Pearson correlation. P-values were computed using the t-approximation.

One-way analysis of variance (ANOVA) was run on individual *Uma* observation data. This is a formal test of the difference between the means of samples. Total variance is partitioned into components due to between-group variation and within-group variation. Contrasts were also run to determine whether or not adults and juveniles differed. Although this is rather redundant given only two groups, it allowed evaluation of confidence intervals (95% CI) about group means.

LizLand Analysis

The LizLand spatial model was based upon primary and secondary data, as well as qualitative and quantitative data. The digital LizLand base map was composed of geomorphic landform and surface composition (MDEP, 2000), heads up digitized sand dunes from MAGTFTC provided DOQ's, and USGS 1:100,000 Digital Line Graph (DLG) hydrology data (USGS, 1989). Unfortunately, the MAGTFTC DOQ's were limited to a very short buffer zone around MCAGCC, thus the LizLand model for the majority of the BLM lands cannot be considered as accurate. The original MDEP (2000) geomorphic landform and surface composition data consisted of 32 geomorphic landform and 24 surface compositions categories. The data were collapsed categories into 10 relevant habitat classes based upon geomorphic landform (i.e. macro landforms), surface composition and relative rockiness: Sand and Gravel, Sandy Wash, Rocky Wash, Sand Sheet, Wind Blown Sand, Erosional Highland, Inselberg, Desert Pavement, Rocky, Playa, and two non relevant habitat classes: Reservoir and Unmapped. The DLG linear hydrology data were buffered 50m on either side to create a 100m wide polygon hydrology data set. The polygon hydrology data were intersected with the 12 habitat classes and then collapsed into two categories: rocky wash or sandy wash. A DLG derived wash was considered rocky if it intersected one of the following habitat classes: Erosional Highlands, Inselbergs, Desert Pavement, Rocky or Rocky Washes. A wash was considered sandy if it intersected Sand and Gravel, Sandy Wash, Sand Sheet, Wind Blown Sand or Playa. Finally, the 12 habitat classes derived from the MDEP (2000) data were merged with the two-category (either rocky or sandy wash) hydrology data set to form a single data layer, the base map of geomorphic classes for LizLand.

Assignment of suitability to any one habitat class was based upon quantitative data (primary fieldwork) and "weight of evidence" qualitative data (existing literature, expert opinion and author knowledge). In both cases we searched for a link between habitat preference and macro landforms via micro landform characterizations.

RESULTS

MCAGCC Training Areas

Tables 4 and 5 show the number and species of herpetofauna located and identified on MCAGCC for summer and fall field seasons, respectively. Figure 3 shows the locations of all *Uma* observed to date from MCAGCC surveys. Figure 4 shows the locations of *Uma*

sightings for the entire survey. In the summer, *Cnemidophorous tigris* was the most abundant species found and *Uma scoparia* was third most abundant. In the fall, *Uma* was by far the most prevalent lizard on the installation with more than 126 individuals identified.

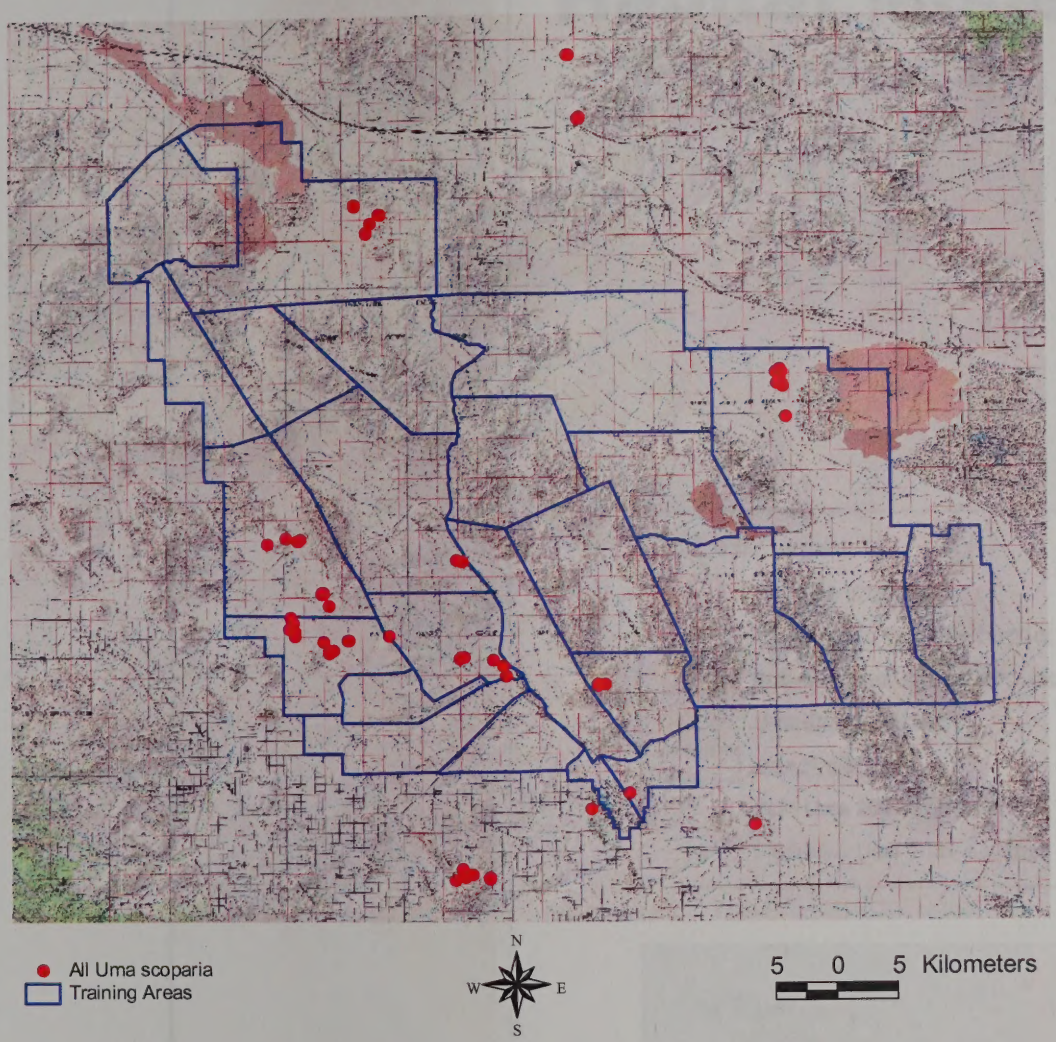


Figure 3. Representation of all *Uma* sightings for 1983-2001.

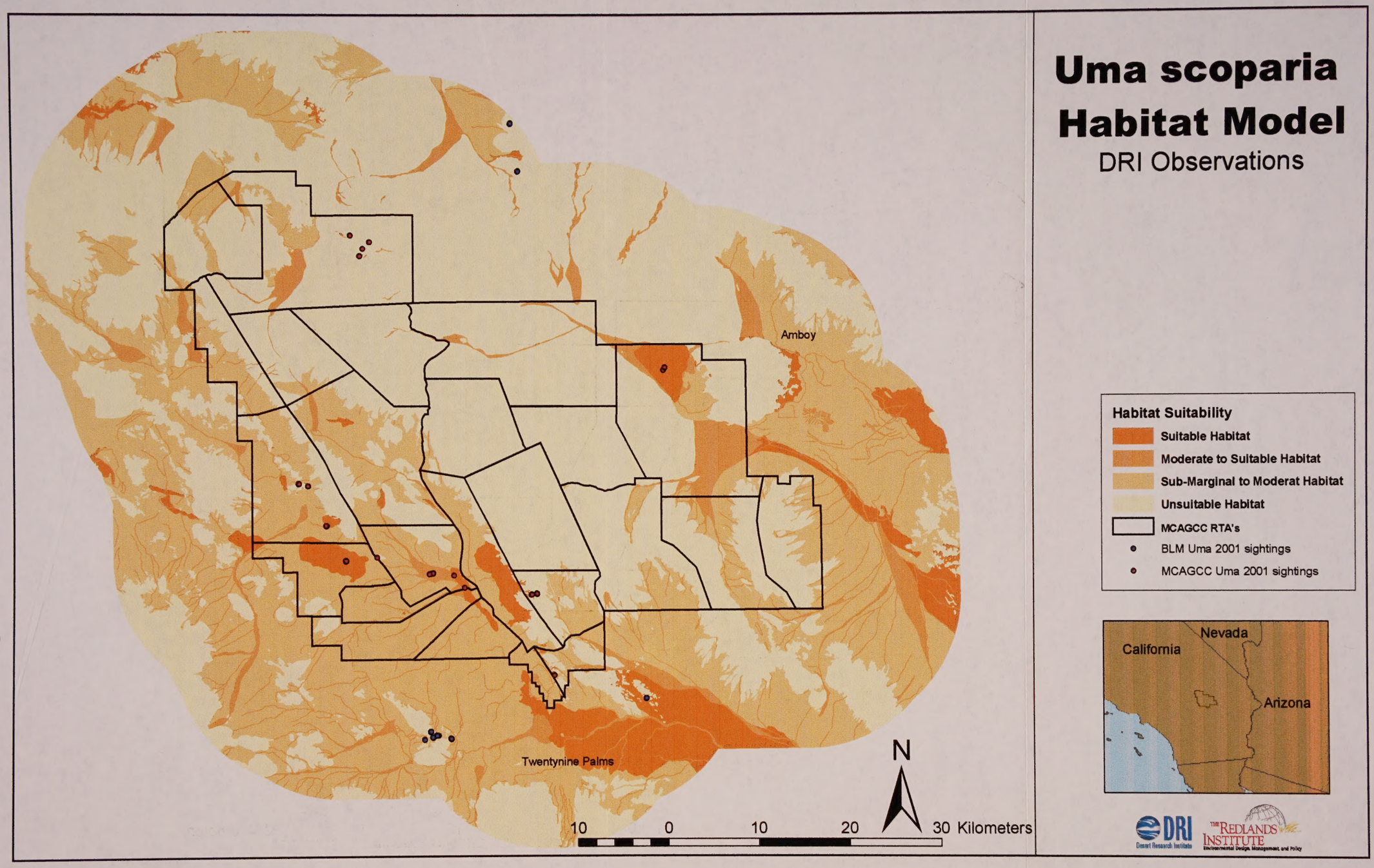


Figure 4. All *Uma* sightings for the 2001 survey.

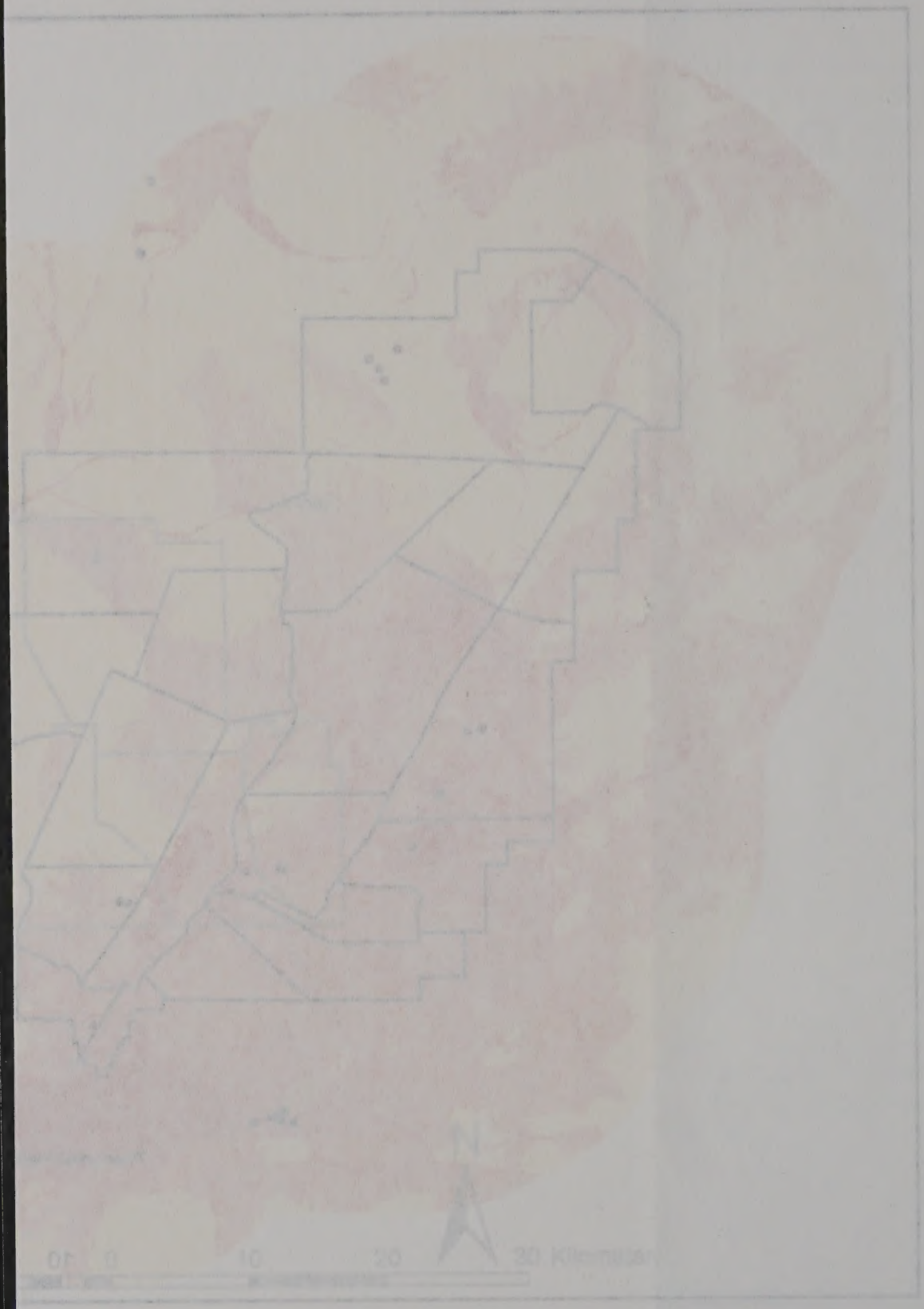

N
0
10
20
30 Kilometers

Table 4. Number and species of lizard observed in the summer sampling period in each MCAGCC Range Training Area, including animals seen outside the individual survey plots.

MCAGCC	Uma*	Cadr	Utst	Cnti	Phpl	Goag	Gawi	Gasi	Dido	Cova
Acorn	6	9	0	11	3	0	0	0	0	0
Emerson Lake	0	2	2	1	4	0	0	0	0	1
Gypsum Ridge	3	0	0	3	1	0	0	0	2	0
Lead Mnt.	0	11	0	1	1	0	0	0	0	0
Lavic Lake	14	5	10	3	8	0	0	0	0	0
Prospect	9	6	4	6	2	0	0	0	2	0
Quackenbush	0	2	0	10	2	0	0	0	1	0
Mainside	0	0	3	0	0	0	0	0	1	0
Maumee Mine	0	1	0	1	1	0	0	0	0	0
Tortoise	0	1	0	13	1	0	0	0	1	0
Total	32	37	19	49	23	0	0	0	7	1

Table 5. Number and species of lizard observed in the fall sampling period in each MCAGCC Range Training Area, including animals seen outside the individual survey plots.

MCAGCC	Uma	Cadr	Utst	Cnti	Phpl	Goag	Gawi	Gasi	Dido	Cova
Acorn	15	0	0	1	1	0	0	0	0	0
Bullion	0	0	0	0	0	0	0	0	0	0
Cleghorn Pass	0	0	0	0	0	0	0	0	0	0
Delta	0	1	0	0	0	2	0	1	0	0
East	0	11	1	5	1	0	3	0	0	0
Emerson Lake	54	22	8	17	5	0	0	0	0	0
Gays Pass	0	0	0	0	0	0	0	0	0	0
Gypsum Ridge	9	9	0	1	0	0	0	1	0	0
Lead Mountain	4	0	0	0	0	0	0	0	0	0
Lavic Lake	0	0	0	0	0	0	0	0	0	0
Prospect	31	3	1	6	0	0	0	0	0	0
Quackenbush	0	1	0	0	0	0	0	0	0	0
Mainside	2	0	2	1	0	0	0	0	0	0
Maumee Mine	0	2	4	5	0	1	0	0	0	0
Total	115	49	16	36	7	3	3	2	0	0

Acorn

The southwest part of this training area consists of a hard packed sand sheet with several washes running throughout the area. The northeast part of the training area consists of a continuous soft packed sand sheet that extends into Emerson Lake. Fifteen juvenile *Uma* were observed here on October 29, 2001 between 1010 and 1149. Vegetation cover was 8%

perennial with no annuals and 98% sand where *Uma* were identified. Figure 5 shows the vegetation cover and Figure 6 shows the surface composition for all plots in Acorn training area, respectively. Air temperature increased from 25 to 29 degrees C, surface temperature increased from 32 to 41 degrees C and subsurface temperature ranged between 26 and 34 degrees C during the survey. There was no wind. All animals identified were juveniles.

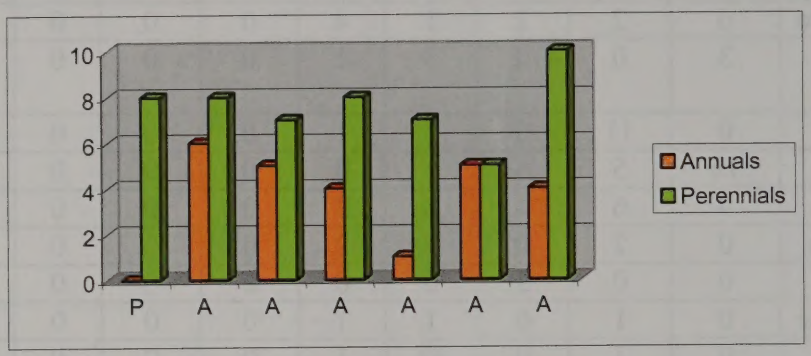


Figure 5. Percent vegetation composition for plots on Acorn RTA. "A" indicates no *Uma* in plots. "P" indicates *Uma* present in plot.

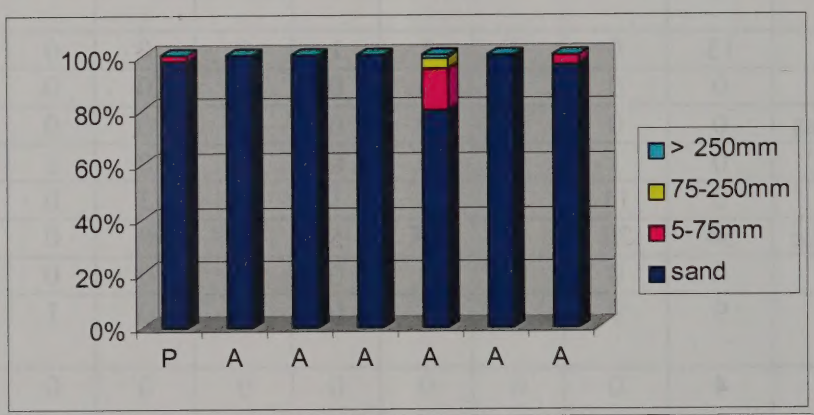


Figure 6. Percent particle size distribution for plots on Acorn RTA. "A" indicates no *Uma* in plots. "P" indicates *Uma* present in plot.

Bullion

This training area is mountainous, with one large valley that acts as a wash. No dune features were identified within this training area in the DOQs and thus no plots were identified for sampling. Therefore this training area was only sampled in the fall using the amended protocol to verify that no habitat pockets existed that were missed in the DOQs. The few sandy areas the field crew found was of a coarse grain that was hard packed. It is also one of the more pristine training areas, with little trash, tracks or unexploded ordnance. No *Uma* were found here.

Cleghorn Pass
The training area has little loose sand, and where sand does accumulate, it has high rock content. In general the area is rocky and hard packed. No dune features were identified within this training area in the DOQs and therefore it was only sampled in the fall. No *Uma* were found here.

Delta
The training area is heavily used in training exercises. A climbing dune exists here but no *Uma* were observed. Three other species were recorded, however, including two tortoises in one burrow. Also two tarantulas were observed.

East
This training area consisted of hard packed, rocky washes. Two juvenile *Uma* were found here on the border of East and Mainside training areas on November 6, 2001. Dune features were identified in the DOQs but these dunes are highly variable in terms of loose sand quality. The individual *Uma* were located in a 99% sand sand sheet (Figure 7). Vegetation cover was estimated to be 2% annuals and 2% perennials. Figure 8 shows the range of vegetation cover for plots surveyed in East Training area. Ambient air temperature remained a constant 25 degrees C while surface temperature increased from 29 to 32 degrees C.

Figure 7. Representation of location of *Uma* sightings (red) on East RTA near Mainside. Survey plots depicted in green and DOQ delineated sand dunes are tan overlaid on 1:24k USGS topographic maps.

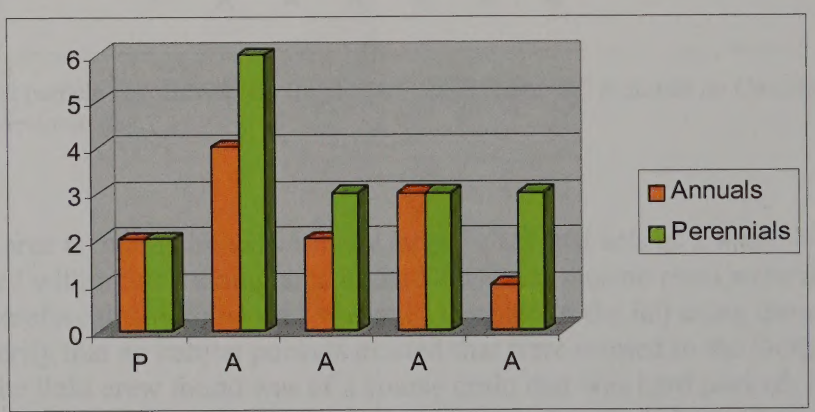


Figure 8. Vegetation composition for plots on East RTA. "A" indicates no *Uma* in plot. "P" indicates *Uma* present in plot.

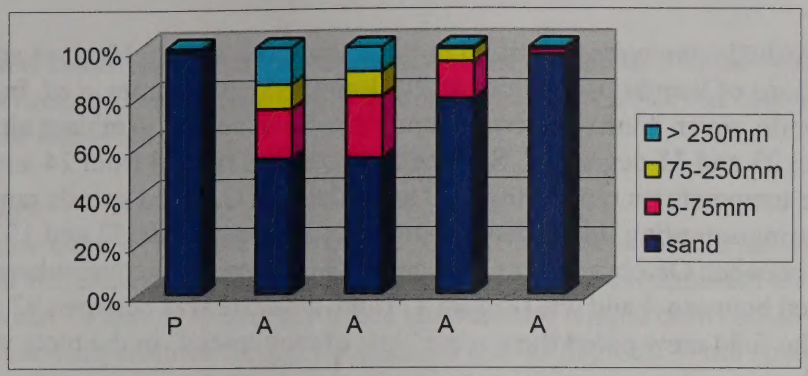


Figure 9. Particle size distribution for plots on East RTA. "A" indicates no *Uma* in plots. "P" indicates *Uma* present in plot.

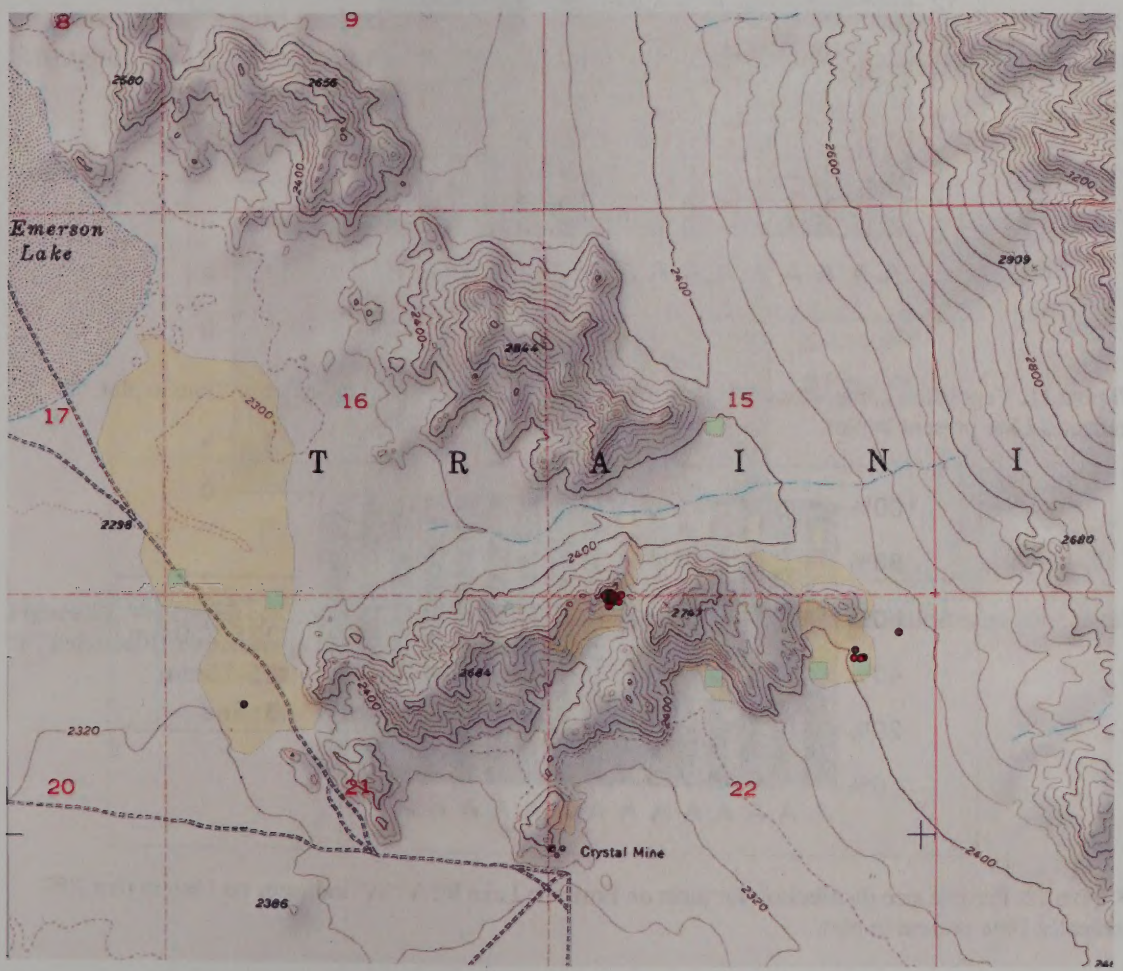


Figure 10. Example of sample plots (green) and locations of *Uma scoparia* identified in year 2001 (red) and in 1982 (purple) for Emerson Lake. Potential dune features identified from DOQs shown in tan.

Emerson Lake

Fifty-four individual *Uma* were identified in Emerson Lake. Figure 10 gives an example of plots and locations of lizard observations in 2001 and 1983 by Fromer *et al.* In 2001 a total of forty-five juvenile, seven adults and two unknown were observed. Ambient air temperature ranged between 23 and 31 degrees C. Surface temperatures ranged from 24 and 44 degrees C and subsurface temperatures ranged from 20 to 43 degrees C. Wind speeds ranged between 0 and 11 mph during sampling. Individuals were observed between 0953 and 1329 on three different days between October 7 and October 24, 2001. Perennial cover where *Uma* were observed ranged between 4 and 7% (Figure 11) and substrate was between 97 and 100% sand (Figure 12). The field crew noted there were "lots of tank tracks" in the plots where *Uma* were observed.

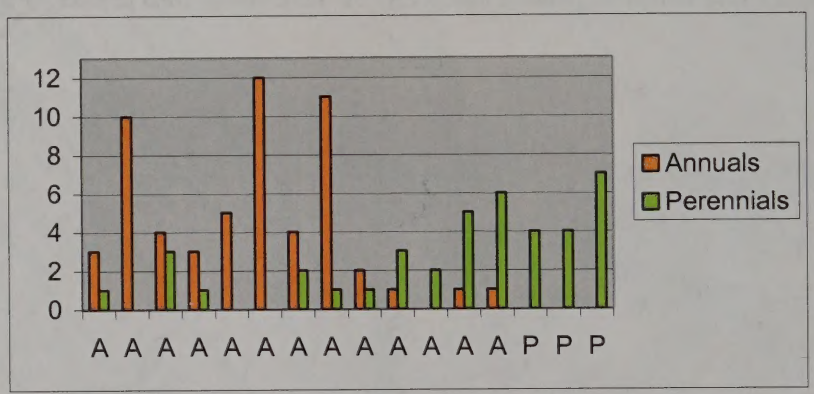


Figure 11. Vegetation composition for plots on Emerson Lake RTA. "A" indicates no *Uma* in plot. "P" indicates *Uma* present in plot.

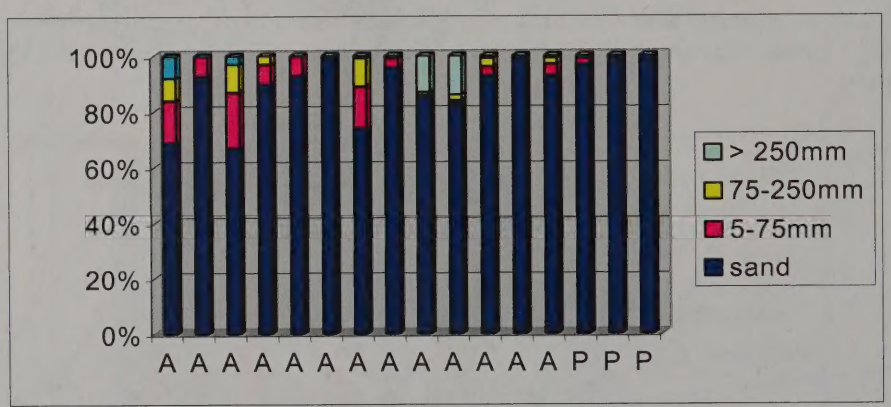


Figure 12. Particle size distribution for plots on Emerson Lake RTA. "A" indicates no *Uma* in plot. "P" indicates *Uma* present in plot.

Gays Pass

The only sand identified in this training area was the coarse sand in the road. Most of the surface was rock, and vegetation was sparse. No *Uma* were observed here and no dune features were identified.

Gypsum Ridge

A total of nine *Uma* were were located here. Individuals were located between 0945 and 1400 on four different dates: 6/12, 7/16, 9/27, and 10/15/2001. Ambient air temperature ranged between 29 and 37 degrees, surface temperature ranged between 25 and 45 degrees, and subsurface temperatures ranged between 26 and 41 degrees. Wind speeds ranged between 0 and 18 km/hr. All *Uma* were observed on sand sheets. Locations which had *Uma* had 7% cover each of annuals and perennials, respectively (Figure 13). The other two locations had no annuals and 4% perennials. Substrate was between 99 and 100% sand although two locations were noted as being "hard pack" (Figure 14). There is hummock habitat throughout this training area and several patches of medium packed sand sheets interspersed with hard packed sheets were noted. Tank tracks were moderately abundant throughout the training area and potential habitat exists throughout the entire training area.

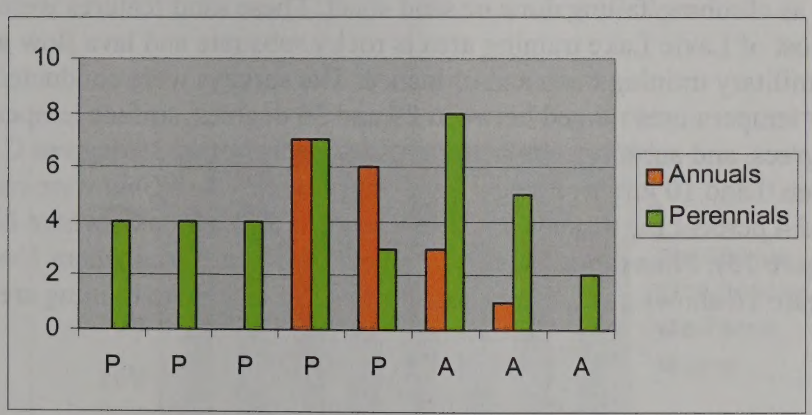


Figure 13. Vegetation composition on plots surveyed in Gypsum Ridge RTA. "A" indicates no *Uma* in plot. "P" indicates Uma present in the plot.

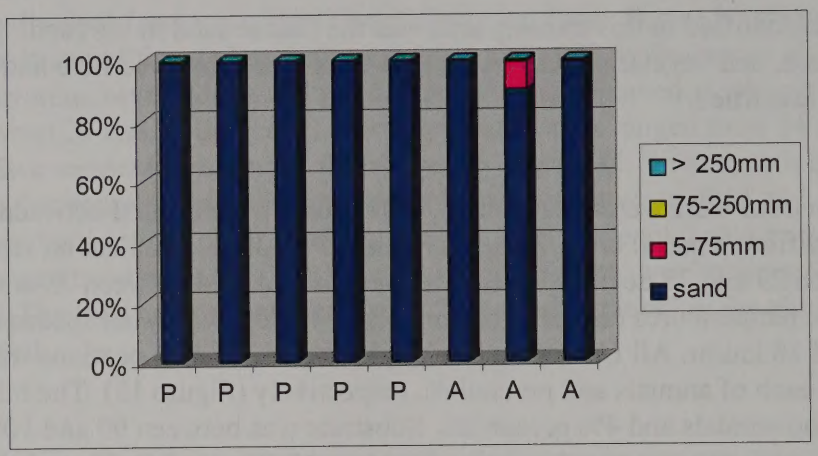


Figure 14. Particle size distribution for plots on Gypsum Ridge RTA. "A" indicates no *Uma* in plot. "P" indicates *Uma* present in plot.

Lavic Lake

Eleven *Uma* were located in four locations in the only potential habitat in this training area characterized as climbing/falling dune or sand sheet. These sand features were identified on the DOQs. Most of Lavic Lake training area is rocky substrate and lava flow and contains a great deal of military training trash and ordnance. The surveys were conducted between 0847 and 1002. Air temperatures ranged between 29 and 36 degrees, surface temperatures between 35 and 50 degrees, and subsurface temperatures between 31 and 35 degrees C. Wind speeds ranged between 0 and 10 km/hr. Percent vegetation cover where *Uma* were observed ranged between 2 and 4 percent for annuals and 5 to 7 percent for perennials where *Uma* were observed (Figure 15). Plots ranged between 63 and 91 percent sand where *Uma* were observed. Figure 16 shows particle size for all plots in Lavic Lake training area.

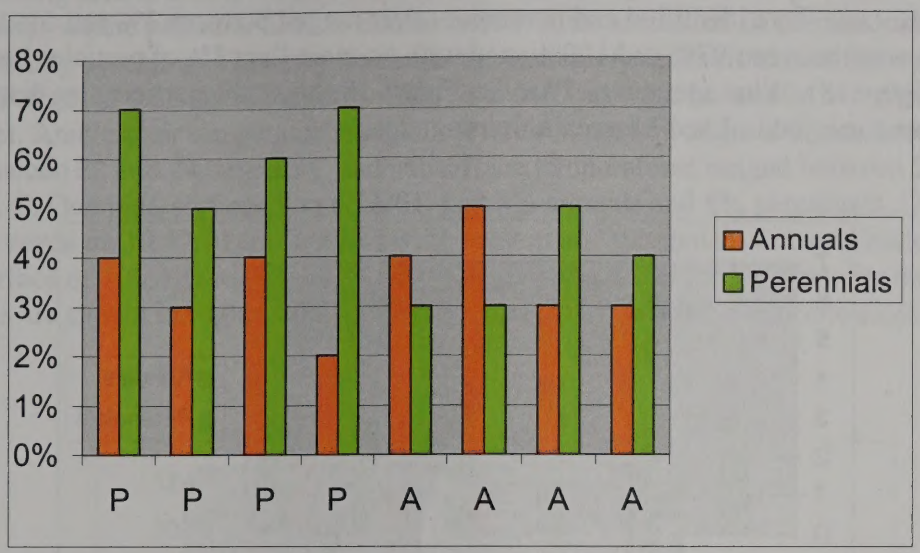


Figure 15. Vegetation composition on plots surveyed in Lavic Lake RTA. "A" indicates no *Uma* in plot. "P" indicates Uma present in the plot.

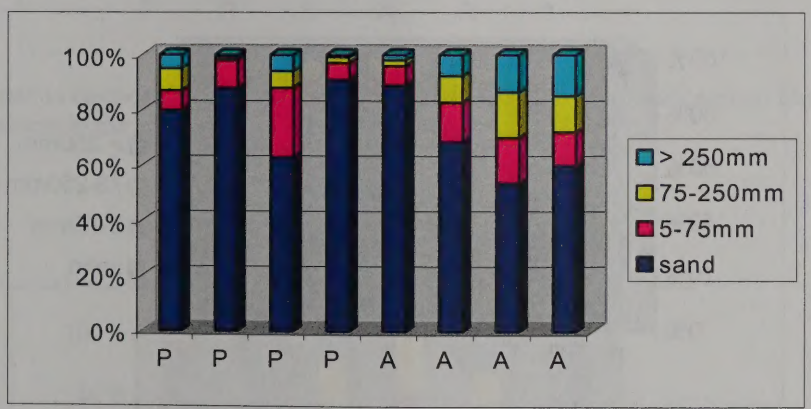


Figure 16. Particle size distribution for plots on Lavic Lake RTA. "A" indicates no *Uma* in plot. "P" indicates *Uma* present in plot.

Lead Mountain

Three *Uma* were identified here, one juvenile and an unknown on 9/24 and one juvenile on 9/25/2001. The surveys were conducted between 0951 and 1210 on what was characterized as a dune sheet. A hard packed rocky sand sheet covers most of this training area and Lead Mountain training area is surrounded by rocky mountains. A small strip of hummock habitat exists in the northern part of the training area, west of Dry Lake. Ambient air temperatures

range between 34 and 40 degrees, surface temperatures ranged between 39 and 47 degrees, and subsurface temperatures ranged between 34 and 47 degrees C. No annuals occurred in plots where *Uma* were identified and perennial cover ranged between 3% and 6% (Figure 17). Plots were between 97% and 100% sand with no more than 3% of particles between 5-75mm (Figure 18). Wind speed was 7 km/hr. Figure 18 shows the particle size distribution for all plots surveyed in Lead Mountain training area.

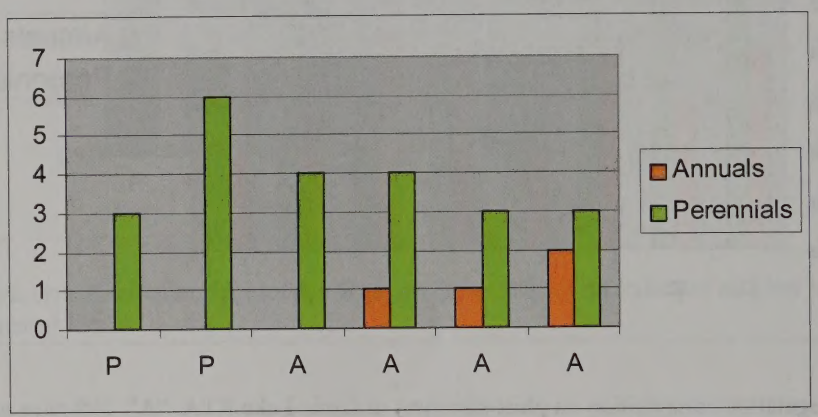


Figure 17. Vegetation composition on plots surveyed in Lead Mountain RTA. "A" indicates no *Uma* in plot. "P" indicates Uma present in the plot.

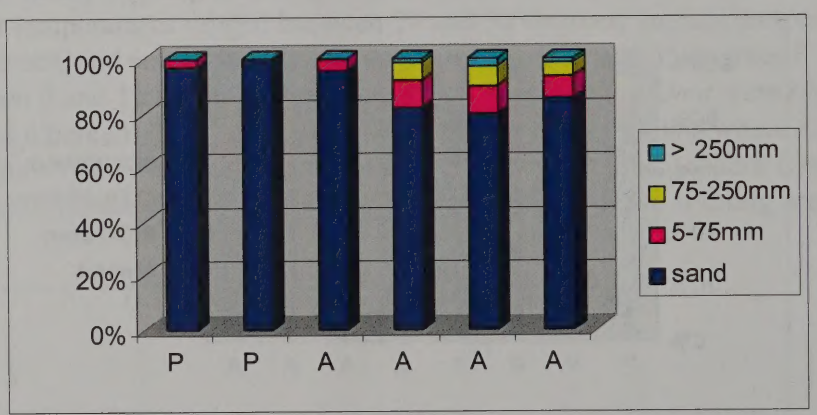


Figure 18. Particle size distribution for plots on Lead Lake RTA. "A" indicates no *Uma* in plot. "P" indicates *Uma* present in plot.

Mainside

This training area is a high use area and is covered in foot traffic, trash, and several running paths. The sand in the area has drifted east into the hills and sand dunes in this training area are soft packed. No *Uma* were found here, but what would appear to be suitable *Uma* habitat does exist.

Prospect

This training area is mostly covered by a continuous rocky sand sheet and is surrounded by mountains. Where potential habitat exists, there is little indication of mechanical disturbance from training or testing. This may be due to the extremely difficult terrain that must be traveled to get to the habitat location. Thirty-seven *Uma* were located at two plots in Prospect. Ambient air temperature ranged between 27 and 32 degrees C, surface temperature was between 22 and 44 degrees C and subsurface temperatures ranged between 22 and 44 degrees C. One plot, surveyed on 6/26/01, had 5% annuals and 8% perennials. On the other plot surveyed on 10/17/01, no annuals were present and perennials were estimated to be 11% on a surface of 100% sand. Figure 19 shows vegetation cover for all plots. Surface substrate for plots are shown in Figure 20. No wind occurred on either of the sample days.

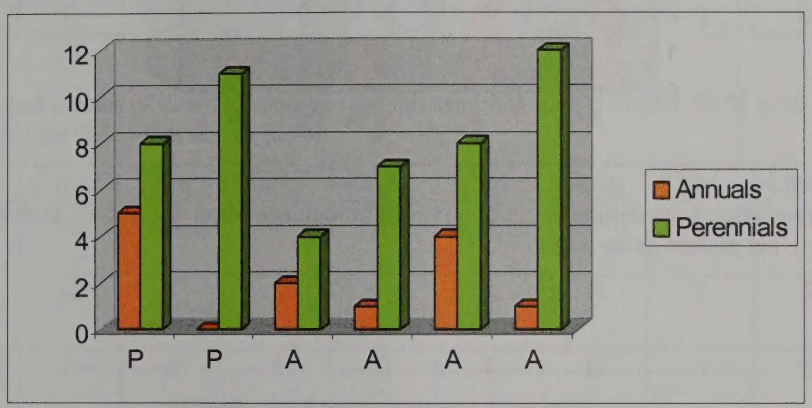


Figure 19. Vegetation composition on plots surveyed in Prospect RTA. "A" indicates no *Uma* in plot. "P" indicates Uma present in the plot.

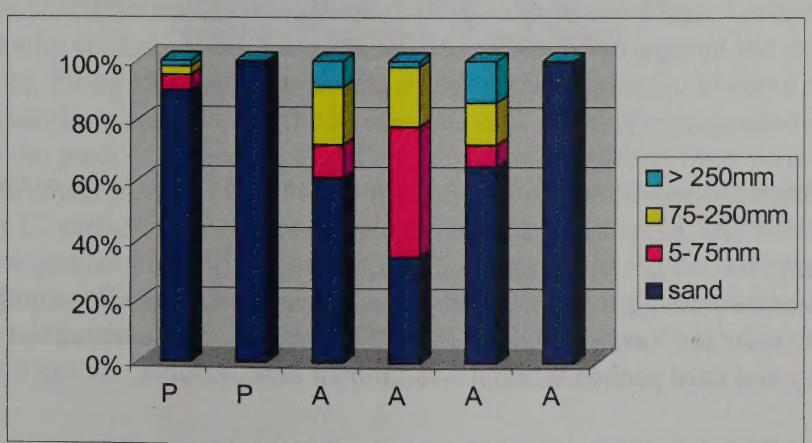


Figure 20. Particle size distribution for plots on Prospect RTA. "A" indicates no *Uma* in plot. "P" indicates *Uma* present in plot.

Maumee Mine

This training area consisted of hard packed rocky substrate. There were several washes throughout the training area. There were small patches of medium packed sand but in the four survey plots no *Uma* were observed. Figure 21 shows the vegetation cover for the four plots surveyed. Figure 22 shows the substrate composition of those same four plots.

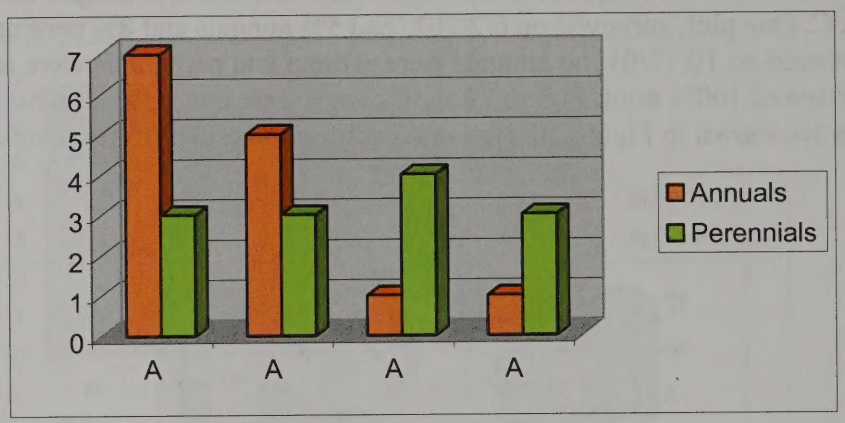


Figure 21. Vegetation composition on plots surveyed in Maumee Mine RTA. "A" indicates no *Uma* in plot. "P" indicates Uma present in the plot.

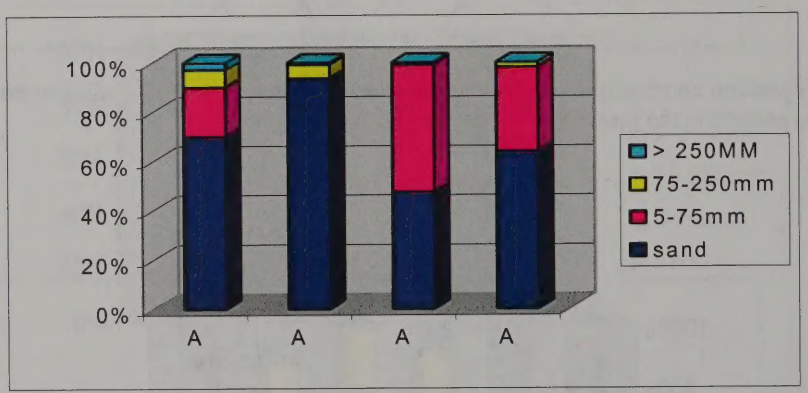


Figure 22. Particle size distribution for plots on Maumee Mine RTA. "A" indicates no *Uma* in plot. "P" indicates *Uma* present in plot.

Quackenbush

One dune feature was digitized in Quackenbush from the DOQs. Closer inspection proved the substrate to be too hard packed for *Uma*. The majority of the remainder of this training area is rocky and hard packed without wind blown sand features.

Tortoise (Restricted Area)

A large medium to hard packed sand sheet covers this training area and there are several large washes throughout the training area. No *Uma* were located here.

BLM Managed Land

Table 6 and Table 7 show the number and species of herpetofauna located and identified on BLM land for summer and fall field seasons, respectively. In the summer, *Cnemidophorous tigris* was the most abundant species found and no *Uma scoparia* were found. In the fall, *Uma* was by far the most prevalent lizard located with 78 individuals identified.

Table 6. Number and species of lizard observed in the summer sampling period in each BLM area, including animals seen outside the individual survey plots.

BLM Areas	Uma	Cadr	Utst	Cnti	Phpl	Goag	Crru	Urgr	Gasi
Spy Mountain	0	0	4	11	1	0	0	0	0
West Mainside	0	3	0	2	0	0	0	0	0
Total	0	3	4	13	1	0	0	0	0

Table 7. Number and species of lizard observed in the fall sampling period in each BLM area, including animals seen outside the individual survey plots.

BLM Areas	Uma	Cadr	Utst	Cnti	Phpl	Goag	Crru	Urgr	Gasi
Bristol Mountain	18	1	0	1	2	0	0	0	0
Copper Mountain	54	1	3	10	0	0	2	5	0
Valley Mountain	6	4	5	0	1	0	0	0	0
Cleghorn Wilderness	0	2	0	0	0	0	0	0	0
Total	0	8	8	11	3	0	2	5	0

Bristol Mountain

This sandy area is visible from National Trails Highway Route 66 near Ludlow, and borders Interstate Highway 40. Loose to medium packed sand exists throughout the land between the two survey plots, filling side canyons and climbing up the mountain. In some areas the wind blown sand has little vegetation, but the lower and level spots have large creosote bushes. It is pristine with no trash or evidence of traffic of any kind. Eighteen *Uma* were located here on two plots surveyed 10/31/01 and 11/07/01. Ambient air temperature ranged between 23 and 28 degrees C, surface temperature ranged from 31 to 44 degrees, and subsurface temperatures ranged between 30 and 46 degrees C. Percent vegetation cover was zero annuals and 6% perennials throughout the area where *Uma* were located. Figure 23 shows the distribution of particle size class. Most (94-98%) of the substrate is sand. Wind ranged between 7 and 9 km/hr.

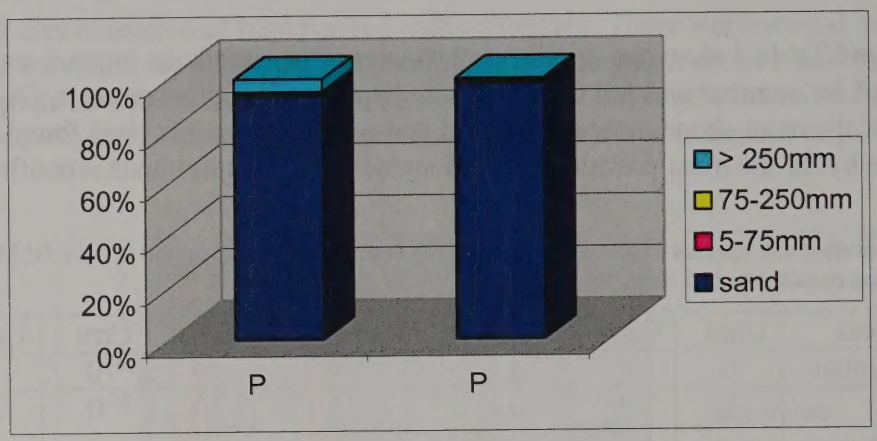


Figure 23. Particle size distribution for plots on Bristol Mountain BLM plots. "A" indicates no *Uma* in plot. "P" indicates *Uma* present in plot.

Copper Mountain

This is a large area that receives a large amount of OHV use on its periphery. It includes one steep dune that is highly tracked, littered with burnt cars, and is devoid of vegetation. The area varies between loose and medium packed sand, and in general is prime habitat. Some of the medium packed areas may not have carried *Uma* if they were isolated, but the area seems to be continuous habitat as it shifts between sand dunes and medium packed sheets. Fifty-four *Uma* were located here during the fall field season. Ambient air temperatures ranged between 25 and 35 degrees C. Surface and subsurface temperatures ranged between 22 and 47, and 21 and 46 degrees C, respectively. Figure 24 shows the percent of annuals and perennials for each of the six plots. Plots were 99-100% sand and wind ranged between 0 and 6 km/hr during sampling.

Spy Mountain

Most of this area consisted of hard packed and rocky substrate. There were a few areas with small soft packed sand, but no *Uma* were seen in these areas.

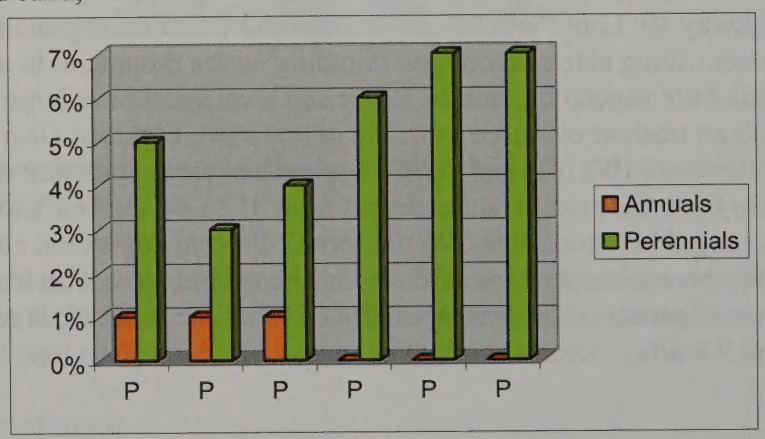


Figure 24. Percent vegetation for Copper Mountain plots.

Valley Mountain
The sand in this area is patchy. When approaching the base of Valley Mountain, the sand becomes hard packed with *Schismus* more prevalent. Two plots were completed in areas of loose sand. Both areas were steep, and vegetation was located in the margins of the dunes, nearing the boulders that encased the dune. In the first area OHV tracks were evident, and no *Uma* were found. In the second area, OHVs had no access due to the topography, and six *Uma* were found. From far away it is apparent that there is potentially additional habitat higher in the mountain, but the field crew was unable to access those areas due to the steepness of the terrain. This area was surveyed on 10/12/01. Ambient air temperature ranged between 25 and 26 degrees C. Surface temperature ranged between 31 and 38 degrees C while subsurface temperatures ranged between 29 and 36 degrees C. Surfaces were 96% sand and 4% rocks (> 250mm). Vegetation was 2% annuals and 4% perennials. Wind speed was 9 km/hr. Figure 25 compares ambient air and surface temperatures for plots with and without *Uma*.

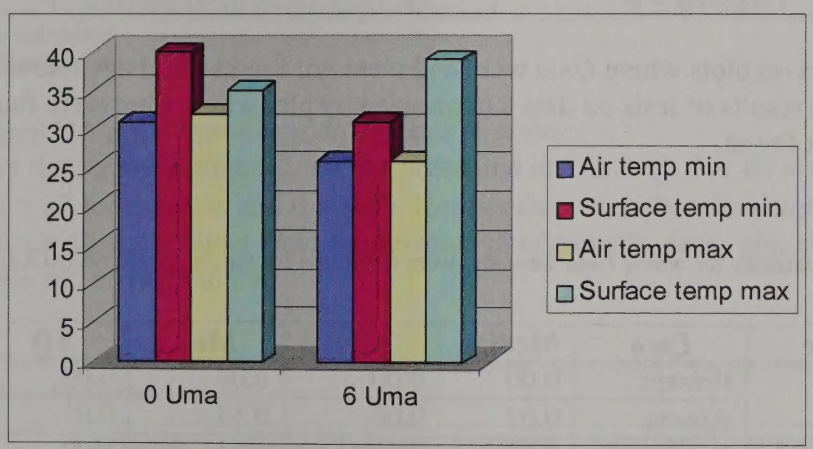


Figure 25. Comparison of temperature in plots with and without *Uma* on Valley Mountain BLM plots.

West Mainside
This area was covered by mesquite. The surface substrate is medium to hard packed sand sheet and no *Uma* were found in the survey plots.

Statistical Analyses

Data Summary
A total of 211 individual *Uma* were identified during the survey periods on seven MCAGCC training areas and in three locations on BLM land. Data were collected on a total of 19 plots on MCAGCC training areas where *Uma* were found while a total of 54 MCAGCC plots had no *Uma*. A total of 77 *Uma* were identified on BLM land in 8 plots, with 10 plots having no *Uma*. For the study area, the highest and the densest number of *Uma* within a single 1 ha plot were found on Prospect (33), followed by two highly dense plots on Emerson (26 and 24

respectively), followed by Copper Mountain (22 and 16). Table 8 summarizes the frequency of individuals per plot where *Uma* were found, on each training area.

Table 8. Number of *Uma* observed per plot for the MCAGCC and BLM sample areas. Dune number refers to the attribute Dune in the BLM and MCAGCC GIS plot coverage's.

Sample Area	Plot #1 (Dune #)	Plot #2 (Dune #)	Plot #3 (Dune #)	Plot #4 (Dune #)	Plot #5 (Dune #)	Plot #6 (Dune #)	total
Prospect	33 (207)	4 (6)					37
Emerson	26 (53)	24 (208)	4 (38)				54
Acorn	15 (210)						15
Lavic Lake	6 (62)	3 (14)	2 (10)	1 (59)			12
Gypsum	3 (202)	2 (203)	2 (206)	2 (205)	1 (91)	1 (71)	11
East	2 (79)						2
Lead Mtn	2 (200)	1 (201)					3
Copper Mtn	22 (106)	16 (101)	9 (107)	4 (105)	2 (108)		53
Bristol Mtn	14 (109)	4 (110)					18
Valley Mtn	6 (103)						6

Basic statistics on plots where *Uma* were and were not found are given below in Table 9. The table includes results of tests on data summarized by plot where *Uma* were found and where *Uma* were not found.

Table 9. Basic statistics for where *Uma* were and were not found for the combined MCAGCC and BLM plot data.

Variable	*Uma*	Median	Min	Max	SD	Range
Annuals	Present	0.00	0.00	0.07	0.02	0.07
	Absent	0.02	0.00	0.13	0.03	0.13
Perennials	Present	0.06	0.02	0.11	0.02	0.09
	Absent	0.04	0.00	0.49	0.09	0.49
Sand	Present	0.99	0.63	1.00	0.08	0.37
	Absent	0.90	0.35	1.00	0.16	0.65
Gravel	Present	0.01	0.00	0.25	0.05	0.25
	Absent	0.07	0.00	0.51	0.11	0.51
Cobble	Present	0.00	0.00	0.08	0.02	0.08
	Absent	0.01	0.00	0.20	0.05	0.20
Stone/Boulder	Present	0.00	0.00	0.06	0.02	0.06
	Absent	0.00	0.00	0.15	0.05	0.15

The results of the F-test for determining statistically significant differences in sample variance between plots with and without *Uma* are presented in Table 10. Statistically significant differences were observed for perennial vegetation cover, sand, gravel, cobble and stone/boulder. However, Shapiro-Wilk W test results, in combination with frequency histograms and normal plots (see APPENDIX 1.), indicated that the majority of data were

non-normally distributed and thus not suitable for parametric methods (i.e., t-test). As a result the non-parametric Mann-Whitney U test was used to determine differences between plots with and without *Uma* for non-normally distributed data, and Analysis of Variance (ANOVA) for normally distributed data.

Table 10. F-test statistical results to determine difference between plots with and without *Uma*.

	F-test	Shapiro-Wilk W
Annuals	1.83	$P < 0.0001$[1]
Perennials	17.37[2]	$P < 0.0001$
Sand	3.82[2]	$P < 0.0001$[1]
Gravel	4.15[2]	$P < 0.0001$[1]
Cobble	6.60[2]	$P < 0.0001$[1]
Stone/Boulder	6.06[2]	$P < 0.0001$[1]
Air temp (start)	1.90	$P < 0.0001$[1]
Air temp (stop)	0.56	$P = 0.3040$
Surface temp (start)	1.59	$P = 0.0002$[1]
Surface temp (stop)	1.49	$P = 0.0020$

[1] Non-normally distributed
[2] Statistically significant at $\alpha = 0.05$

Mann Whitney U test for significant differences in habitat

Results from the Mann-Whitney U test are presented in Table 11. For all tests, N = 63 for presence, N = 27 for absence, and $\alpha = 0.05$. Results show that there is a significant difference between plots with and without *Uma* for percentage of annuals, sand, gravel, cobble, but not for perennials and stone/boulder.

Table 11. Mann Whitney U test results between plots with *Uma* and without *Uma* for annuals, perennials, sand gravel, cobble, and stone/boulder.

Variable	*Uma* Presence/Absence	Median	P Value
Annuals	Present	0.00	0.0006[1]
	Absent	0.02	
Perennials	Present	0.06	0.5379
	Absent	0.04	
Sand	Present	0.99	0.0006[1]
	Absent	0.90	
Gravel	Present	0.01	<0.0001[1]
	Absent	0.07	
Cobble	Present	0.00	0.0054[1]
	Absent	0.01	
Stone/Boulder	Present	0.00	0.1205
	Absent	0.00	

[1] Statistically significant at $\alpha = 0.05$

Differences in temperature data

Temperature data at the start of surveys ranged between 23°C and 39°C. The maximum start air temperature at the plot level was 36°C and the maximum surface temperature at the start of plot surveys was 46°C. Table 12 summarizes temperature observations for individual *Uma* observations.

Table 12. General temperature statistics for fall field survey *Uma* observations.

	Air temp (°C)	Surface temp (°C)	Subsurface temp (°C)
Mean	29	37	34
Median	29	37	34
Min	23	22	20
Max	40	49	47
Std dev	3.1	4.4	4.7
Range	17	27	27

Breaking down the individual *Uma* observation by age, adults were observed when air temperatures ranged between 24-29°C while juveniles were observed between 23-40°C. The same is true for surface and subsurface temperatures as well. Surface temperatures where adults were observed ranged between 34-41°C and between 22-49°C for juveniles. Subsurface temperatures where adults were observed ranged between 27-41°C and between 20-47°C for juveniles.

To compare, we looked at the difference in surface and ambient air temperatures in plots where *Uma* were and were not observed. Table 13 shows the results from the Mann Whitney U test for start and finish ambient air temperature and start and finish surface temperature. For all tests, $N = 63$ for presence, $N = 27$ for absence, and $\alpha = 0.05$. The only significant difference was in the air temperature at the start of surveys between plots where *Uma* were and were not found ($\alpha = 0.05$, $p = 0.0053$).

Table 13. Mann Whitney U test results between plots where *Uma* were (present) and were not observed (absent) for air and surface temperature measurements.

Plot Temperature Variable (°C)	*Uma*	Median	P Value
Start Air	Present	31	0.0053[1]
	Absent	29	
Start Surface	Present	35	0.5112
	Absent	34	
Finish Air	Present	32	0.1259
	Absent	33	
Finish Surface	Present	40	0.5700
	Absent	38	

[1] Statistically significant at $\alpha = 0.05$

Simply summary statistics on temperature data of individual observations from the fall field survey are presented in Table 14, below. These are the results from data collected only for observed *Uma* during the exploratory season. Twelve adults, 160 juveniles, and 20 unknown aged *Uma* were observed and comprise this data set.

Table 14. Simple summaries of temperatures taken where individual *Uma* were observed during the fall field season. Temperature in degrees C.

Temperature		N	Mean	SD	Median	95% CI of Mean
Air Temp	Adult	12	26.583	1.5050	26.000	25.627 to 27.540
	Juv	160	28.850	2.9847	28.000	28.384 to 29.316
	Unk	20	31.600	3.0332	32.000	30.180 to 33.020
Surfac Temp	Adult	12	36.750	2.3404	37.000	35.263 to 38.237
	Juv	160	36.731	4.4421	37.000	36.038 to 37.425
	Unk	20	39.250	4.7337	39.500	37.035 to 41.465
Sub- Surface Temp	Adult	12	34.000	3.5162	34.000	31.766 to 36.234
	Juv	160	34.075	4.8064	34.000	33.325 to 34.825
	Unk	20	34.900	4.3030	34.500	32.886 to 36.914

ANOVA results for age observations

Results from the ANOVA test between various age classes and temperature variables are presented in Table 15. For all test, N = 12 for adults, N = 160 for juveniles, N = 20 for unknown, $\alpha = 0.05$, and df = 2. There was a significant difference between air temperatures for detecting adult versus juvenile lizards, with juveniles seen at higher temperatures.

Table 15. ANOVA results between adult and juvenile temperature recordings.

Observation Temperature Variable	*Uma* Age class	Mean Temp. (°C)	P Value
Air	Adult	27	<0.0001[1]
	Juvenile	29	
	Unknown	32	
Surface	Adult	37	0.0542
	Juvenile	37	
	Unknown	39	
Sub-surface	Adult	34	0.7547
	Juvenile	34	
	Unknown	35	

[1] Statistically significant at $\alpha = 0.05$

Spearman-rank correlation

Table 16 summarizes the results of the correlation analysis between habitat variables and *Uma* frequency in plots. A negative spearman-rank correlation coefficient indicates a negative correlation while positive values indicate positive relationship. Values approximating zero indicate no relationship while values approaching one indicate high degree of correlation.

Table 16. Spearman-rank correlation results for habitat and temperature variables against *Uma* counts.

Habitat variable	Coefficient	p-value
Annuals	-0.40	< 0.0001[1]
Perennials	0.10	0.3475
Sand	0.36	0.0004[1]
Gravel	-0.35	0.0007[1]
Cobble	-0.29	0.0057[1]
Stone/Boulder	-0.16	0.1291
Air temp (start)	-0.37	0.0004[1]
Air temp (stop)	-0.21	0.0481[1]
Surface temp (start)	-0.13	0.2190
Surface temp (stop)	0.10	0.3668

[1] Statistically significant at $\alpha = 0.05$

Approximately half of the variables showed a statistically significant correlation with *Uma* frequency in plots. No relationship was indicated between the number of *Uma* observed in a plot and the percentage of perennial cover. There was an inverse relationship between *Uma* count and percentage of annual vegetation. Higher counts of *Uma* were statistically significantly correlated with higher percentage of sand cover; and there exists an inverse relationship between numbers of *Uma* and percent gravel and cobble cover. There was no significant relationship between *Uma* count and stones or boulders. The temperature at the start of surveys was negatively and significantly related to count. Statistically, the air temperature at the completion of surveys was significant but this can be considered a weak relationship at best. There was no significant relationship between the number of individuals observed and ambient air temperatures at the beginning and end of surveys.

To determine if time of day (0700-1430) may have affected the survey crew's ability to observe individuals, Spearman rank correlations were run on time of day and temperatures. No correlation existed between time of day and number of individual *Uma* observed ($rs = -0.01$ $p = 0.8863$). Surface temperature was positively correlated to time of day ($rs = 0.35$ $p < 0.0001$). Subsurface temperature was positively correlated to time of day ($rs = 0.57$ $p < 0.0001$).

Linear regression

Multiple linear regression was run on frequency data where *Uma* were observed to develop a linear model between number of individuals and habitat variables. The residual plot for the full model is shown below (Figure 26) and indicates the need for a transformation of the response variable ($R^2 = 0.13$, adjusted $R^2 = 0.07$):

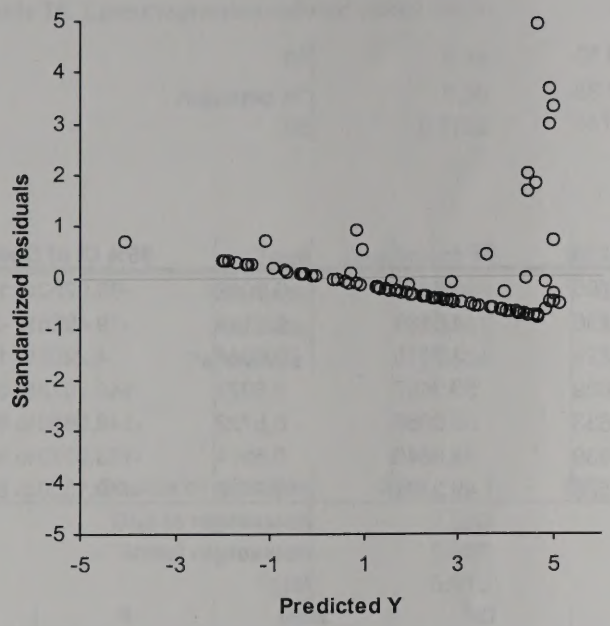


Figure 26. Linear regression residual plot.

The log transformation cannot be computed for values of zero, therefore regressions were run on presence data only. The best model fit on positive observations and all of the physical habitat variables is presented below (Table 17):

LOG(U) = 29.38 –11.11(a) + 12.07(p) – 29.27(s) – 32.16(m) – 31.49(l) – 16.15(c)

where U = number of *Uma* observed in a plot
a = % annuals
p = % perennials
s = % particles < 5mm (sand)
m = % particles 5-75mm
l = % particles 75-250mm
c = % particles > 250mm (cobbles)

Table 17. Linear regression full model results.

R^2	0.53
Adjusted R^2	0.38
SE	0.3746

Term	Coefficient	SE	p	95% CI of Coefficient
Intercept	29.3786	55.3240	0.6012	-86.0252to 144.7825
Annuals	-11.1136	4.0169	0.0119	-19.4926to -2.7345
Perennials	12.0729	3.7615	0.0044	4.2265to 19.9193
COV<5	-29.2689	55.3407	0.6027	-144.7075to 86.1697
COV5_75	-32.1633	56.0056	0.5722	-148.9889to 84.6623
COV75_250	-31.4939	58.6846	0.5974	-153.9079to 90.9201
COV>250	-16.1508	49.3701	0.7470	-119.1350to 86.8334

Source of variation	SSq	DF	MSq	F	p
Due to regression	3.106	6	0.518	3.69	0.0124
About regression	2.807	20	0.140		
Total	5.913	26			

Based on these results, a reduced model was fit that produced comparable adjusted R^2 values, but was based on only vegetation data (Table 18). Only adjusted R^2 values can be compared because the number of explanatory variables are not equal in the two regression analyses.

$$LOG(U) = 0.1325 - 10.34(a) + 11.84(p)$$

where U = number of *Uma* observed in a plot
a = % annuals
p = % perennials

Table 18. Linear regression reduced model results.

R^2	0.44
Adjusted R^2	0.39
SE	0.3722

Term	Coefficient	SE	p	95% CI of Coefficient
Intercept	0.1325	0.2084	0.5310	-0.2977to 0.5627
Annuals	-10.3381	3.4892	0.0068	-17.5395to -3.1367
Perennials	11.8434	3.5460	0.0027	4.5249to 19.1620

Source of variation	SSq	DF	MSq	F	p
Due to regression	2.589	2	1.294	9.34	0.0010
About regression	3.325	24	0.139		
Total	5.913	26			

LizLand

The MCAGCC LizLand model is presented in Figure 27 and the California GAP (CA-GAP) model in Figure 28. *Uma* is restricted to wind blown sand habitats in the LizLand model. Only 5% of MCAGCC is considered Suitable Habitat according to the LizLand model. In contrast, CA-GAP identifies 92% of MCAGCC as "suitable", and only 1% of MCAGCC as completely unsuitable. The remaining 7% is in varying stages of suitability. According to LizLand 42% of MCAGCC is represented by Moderate to Suitable Habitat (6% from sandy washes, the remaining 36% sand and gravel), 29% is Sub-Marginal to Moderate Habitat, and 24% is Unsuitable Habitat. In all cases, from Suitable to Unsuitable the actual amount of suitable habitat is less then the LizLand areal estimate. This is due to the heterogeneous, patchy nature of sandy habitats. However, the qualitative probability of finding sandy habitat within Suitable Habitat is markedly higher then in Moderate to Suitable Habitat, which in turn is higher then in Sub-Marginal to Moderate Habitat, and so forth. This should not be confused with LizLand model accuracy, which would be due to model error or source data error. As such, the area found within the confines of the Suitable Habitat boundaries should be consider "suitable" regardless of the presence of *Uma* at a particular point in space. The Suitable Habitat is intended to capture the entire matrix of necessary habitat requirements that in some cases includes hummocky, loose sandy habitats within a matrix of compact soils. The LizLand model for MCAGCC displayed by RTA and BLM area are given in Appendix 2 and Appendix 3, respectively.

DISCUSSION

Twenty-four training areas exist on MCAGCC and *Uma* were found to occur on seven of those areas (Figure 29). The primary reason for the occurrence of *Uma* is that there exists suitable habitat for this species to occur and persist. Figure 3 presented all *Uma* sightings recorded for MCAGCC for all studies as well as the *Uma* sightings on adjacent BLM lands recorded during the 2001 study. Evaluating the spatial distribution of *Uma*, it is most likely

the case that these animals are reproducing within installation boundaries, and that MCAGCC may be a source, rather than a sink for its *Uma*. If MCAGCC were a sink for *Uma*, meaning that individual animals could exist within base boundaries but there did not exist a reproducing population, rather individuals entered the base from an external dispersion point, several conditions would have to exist that were not found to exist during the course of this study.

The first condition is that at least one source population would have to exist outside of MCAGCC boundaries from which individuals would disperse onto MCAGCC. *Uma* were found at three locations in the 2001 field season on BLM lands and in the past, *Uma* were also found outside MCAGCC in an additional location (Sanders and Sylber,1990). The distance between the *Uma* sighting in 1990 and the closest *Uma* observed on MCAGCC, on East Range, is 3.3km. While it is unknown if this distance is an unrealistic dispersal distance for *Uma*, the anthropogenic obstacles and fragmentation most likely serve as barriers to dispersal. Between the two locations are a maze of roads, buildings, other paved surfaces, and non-habitat. Additionally, there is no evidence that the 1990 sighting is indicative of a reproducing population as it contains only one sighting. The distances between the other two locations in the vicinity where *Uma* were located outside MCAGCC, Copper Mountain and Valley Mountain, and the occurrences on East range are 13km and 10.5km, respectively. It is highly unlikely that *Uma* are dispersing from these two locations onto MCAGCC due to the lack of habitat and the development between the respective locations. To the north of MCAGCC is the Bristol Mountain sighting location and the closest MCAGCC sightings (Lavic Lake) are more than 18km away. Both adults and juveniles were observed at Bristol Mountain (18 total). On Lavic Lake, *Uma* were observed both by Cutler *et al.* (1999) and during the 2001 field survey (12 individuals).

The second condition that would indicate MCAGCC is a sink for *Uma* and does not harbor reproducing populations would be that adults and juveniles were not identified on MCAGCC. Again, this condition was not found to be true, rather the evidence supports the contrary. Both adults and juveniles were found to occur on MCAGCC in multiple training areas. During the fall field season 12 adults and 160 juveniles were positively identified. Another 20 individual *Uma* were identified but age was not obviously determinable.

Based on the results from the 2001 survey, the evidence indicates that MCAGCC does support viable, reproducing populations of *Uma* and does not serve solely as a sink for this species. That is, animals are living and reproducing within installation boundaries. Furthermore, it seems unlikely that individuals are dispersing onto MCAGCC land from outside installation boundaries. What remains unclear is whether this geographic distance between what would comprise metapopulations is due to modern development and acitivies or is relict from landscape conditions dating back to historic times.

Clearly, studies of *Uma* dispersal coupled with genetic analyses of populations on and off MCAGCC would provide a better picture of the historic and present interactions of populations in the general southern Mojave Desert, centering on MCAGCC. However, given the evidence from our survey (2001) it appears that both MCAGCC and BLM harbor reproducing populations of *Uma scoparia*. The extent to which these populations exhibit

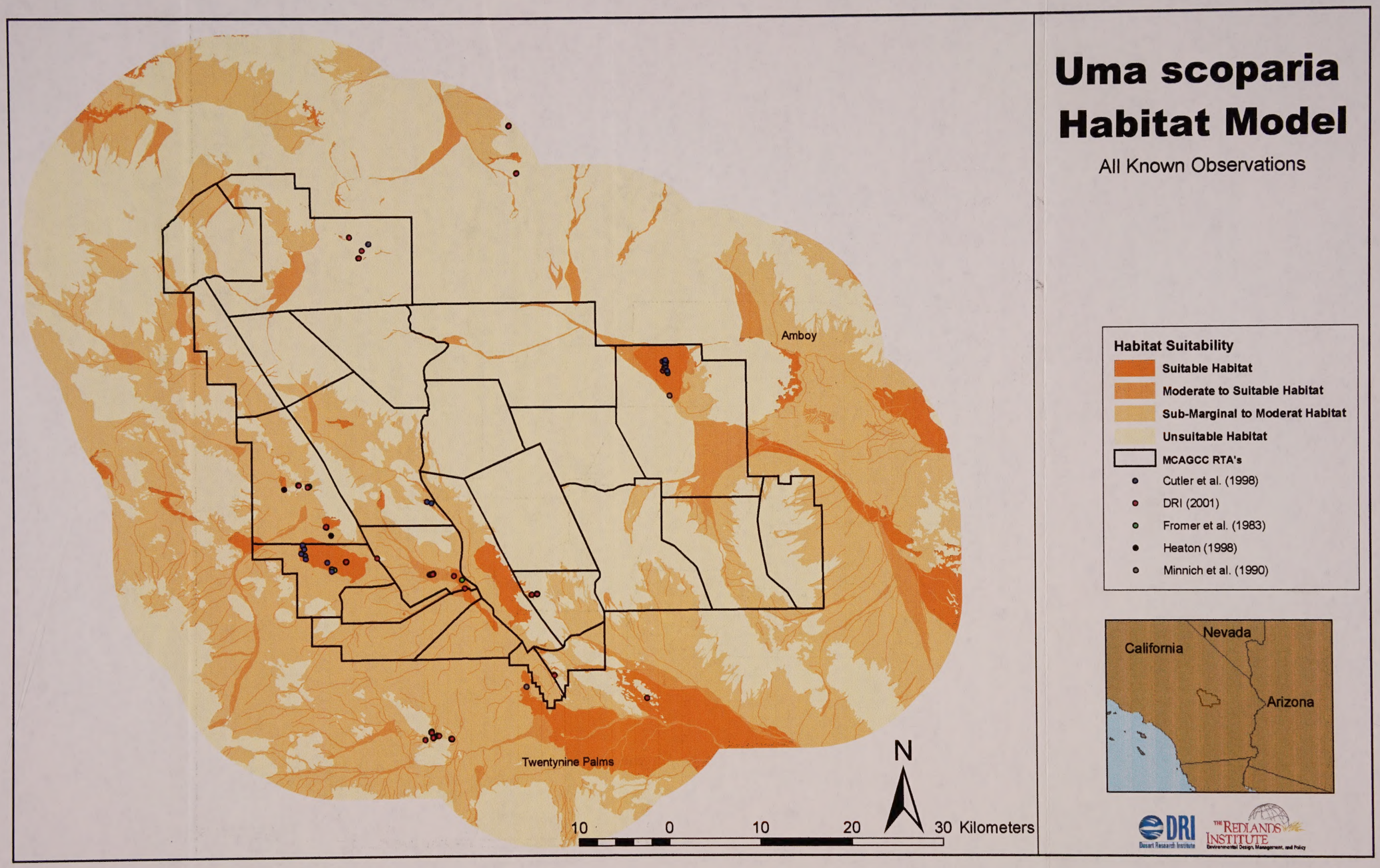
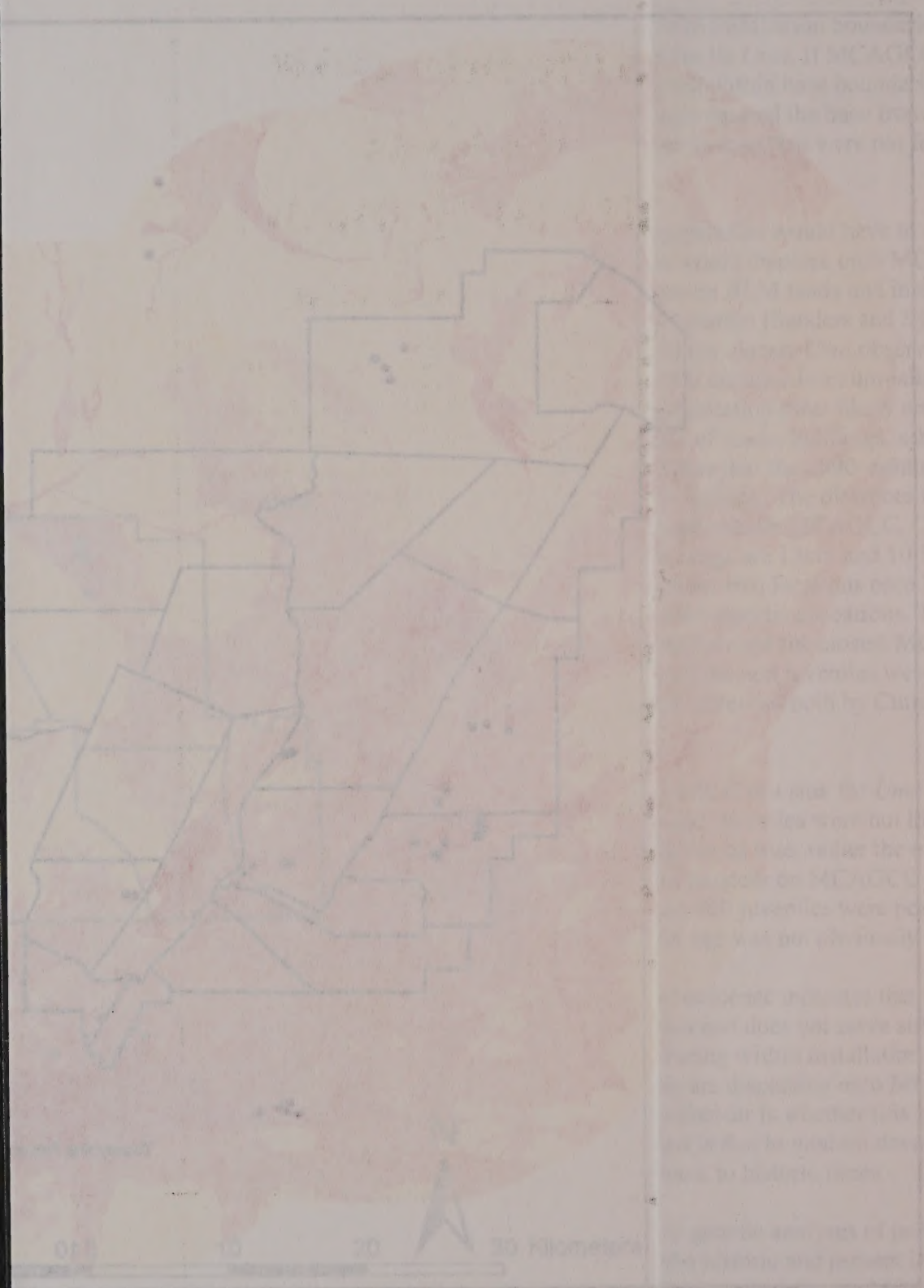
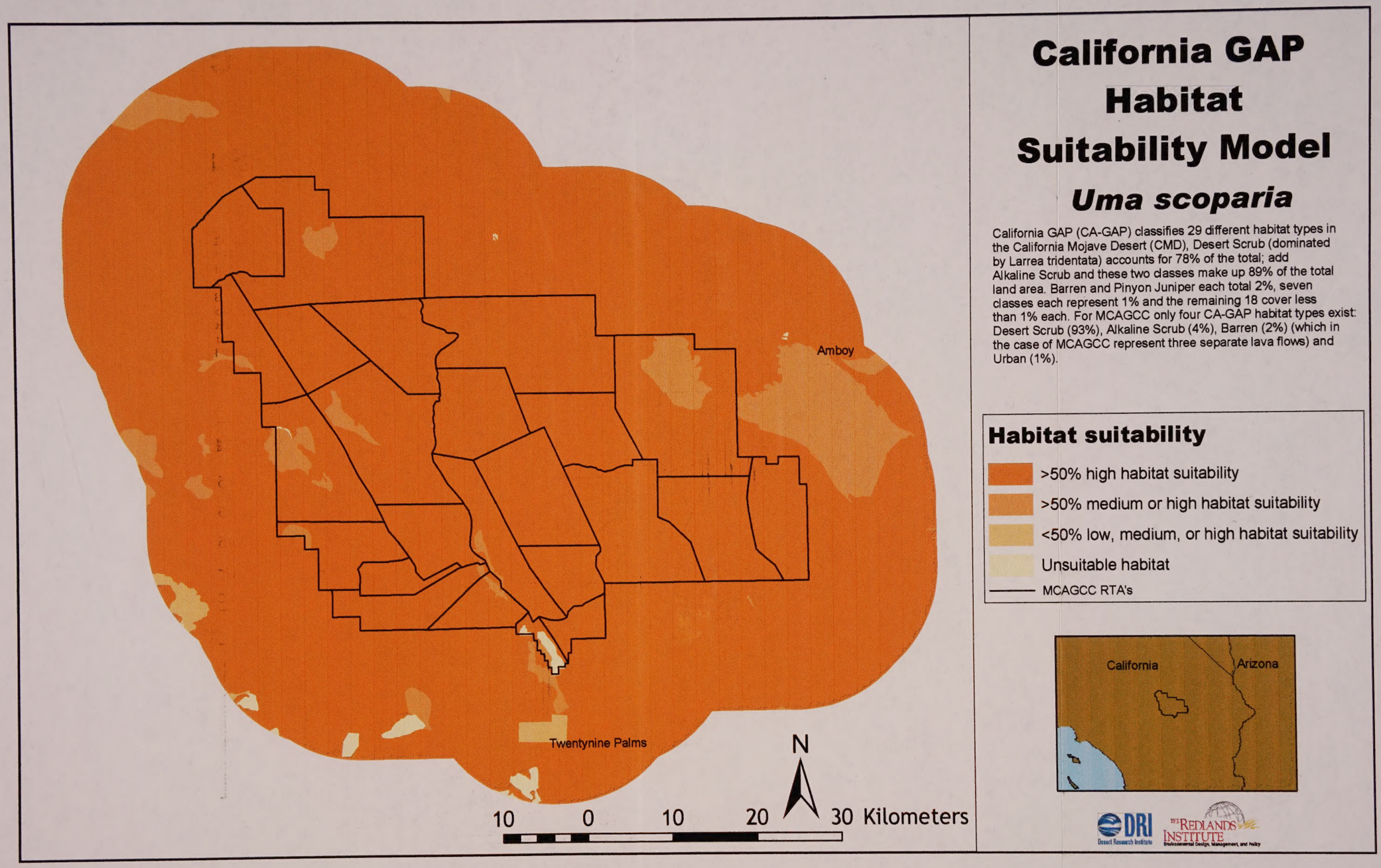


Figure 27. MCAGCC Lizland model along with all recorded *Uma* observations 1983-2001.





California GAP Habitat Suitability Model

Uma scoparia

California GAP (CA-GAP) classifies 29 different habitat types in the California Mojave Desert (CMD), Desert Scrub (dominated by Larrea tridentata) accounts for 78% of the total; add Alkaline Scrub and these two classes make up 89% of the total land area. Barren and Pinyon Juniper each total 2%, seven classes each represent 1% and the remaining 18 cover less than 1% each. For MCAGCC only four CA-GAP habitat types exist: Desert Scrub (93%), Alkaline Scrub (4%), Barren (2%) (which in the case of MCAGCC represent three separate lava flows) and Urban (1%).

Habitat suitability

- >50% high habitat suitability
- >50% medium or high habitat suitability
- <50% low, medium, or high habitat suitability
- Unsuitable habitat
- MCAGCC RTA's

Figure 28. California GAP model for *Uma*.

100
200
30 Kilometers

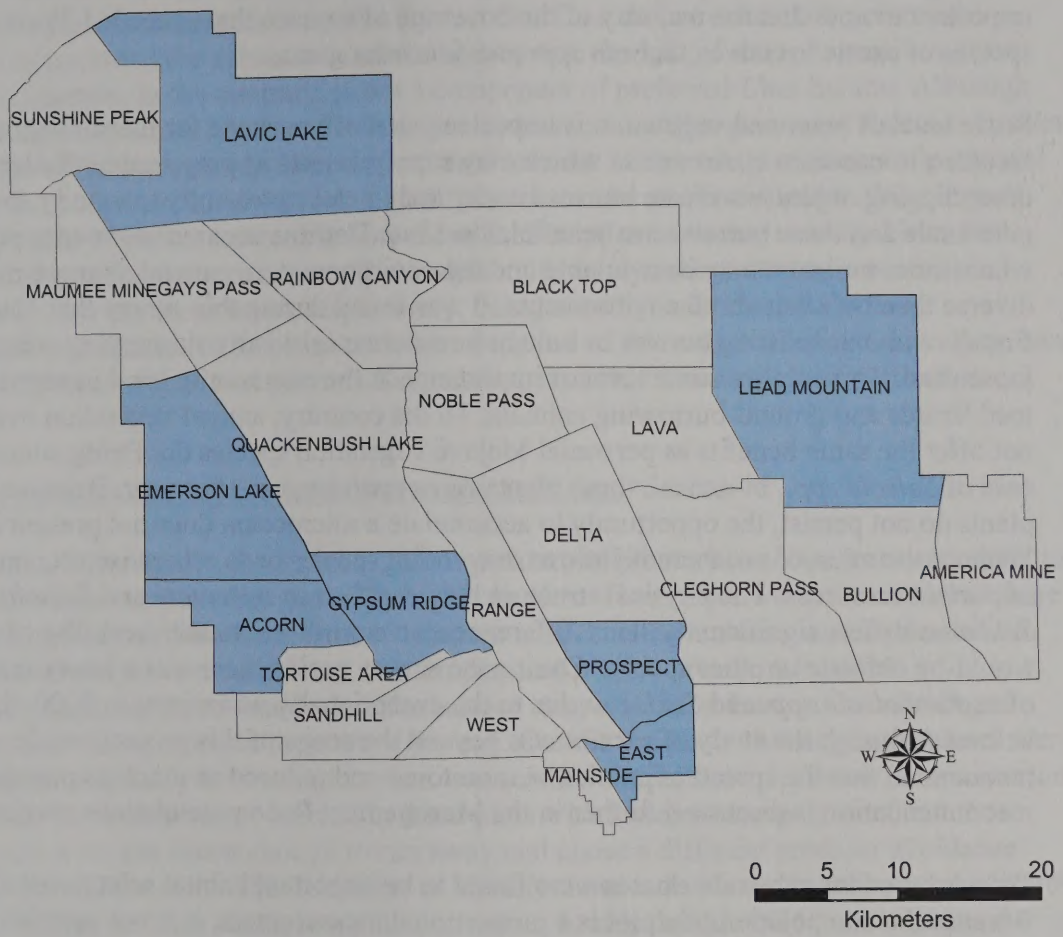


Figure 29. RTAs shown in blue were found to harbor *Uma scoparia* while those shown in white did not harbor *Uma scoparia*.

fitness, particularly from a genetic perspective, remains unknown at this time. Population estimates and genetic analyses would provide insight and definitive answers regarding fitness and status of these populations, as well as defining metapopulations in the area.

Significance of Mann-Whitney tests on cover variables

A great deal of data were collected and analyzed at the plot level to evaluate biotic and abiotic habitat characteristics of *Uma*. There are significant differences between locations that harbor *Uma* and locations where *Uma* were not found to occur. Two biotic parameters were evaluated, percent annuals and percent perennials. There was a significantly lower percentage of annuals on plots where *Uma* occurred but there was no difference in perennial

cover. In other words, the amount of perennial vegetation does not seem to impact presence/absence, and on MCAGCC and the surrounding BLM land this vegetation would be primarily *Larrea.* However not any type of vegetation is appropriate, as *Uma* do appear to select against locations where there are, in general, more than 2% cover of annuals. It is important to note that the majority of the coverage of annuals that exceeded 2% were two species of exotic invasives, *Salsola spp.* and *Schismus* grass.

Some level of perennial vegetation is important, as it offers shade for thermoregulation and creates a microcosm environment which may supply insects as prey source. Rodents and other digging organisms create burrows under and in close proximity to woody, brushy perennials and these burrows are beneficial to *Uma*. Detritus accumulates under perennials where more moisture may be available and the environment, in general, is more rich and diverse than between-shrub environments. It was found during this survey that *Uma* would first dive into an existing burrow or hole before characteristically shimmying subsurface in loose sand. This implies some level of importance at the community level in terms of fringe-toed lizards and ground-burrowing animals. To the contrary, annual vegetation over 2% does not offer the same benefits as perennial Mojave vegetation species do. Being annual, or in the case of *Salsola spp.*, bi-annual, these plants do not persist year after year. Because these plants do not persist, the opportunity to accumulate a microcosm does not present itself. Without the microcosm, there is little to draw other species or to otherwise accumulate important resources. The physical structure between *Larrea tridentate* and *Salsola spp.* or *Schismus* differs significantly. This difference also contributes to the useability of plants by would-be obligate or other species. During the survey period there was a heavy standing crop of exotic *Salsola spp.* and *Schismus* due to the exceptionally wet winter in 2000, the year before. Although the study of exotics was beyond the scope of this project, we do recommend that the spread of exotics be monitored and reduced as much as possible. This recommendation is discussed further in the Management Recommendations section.

Three of the four substrate classes were found to be important habitat selection variables. Because the composition of a plot is a proportional measurement, it is not surprising that differences in percent sand appear to be very similar, upwards of 90% for plots with and without *Uma*. There is a very significant difference, however, in what would otherwise appear to be marginal differences in amount of sand. *Uma* prefer areas with higher sand proportions. Particle sizes greater than 250mm, mainly stones and boulders, were just as abundant where *Uma* were located as where they were not. It should be noted that because sand dunes and sheets were specifically selected for surveying and these features typically do not contain significant amounts of stones and boulders, areas with high amounts of stones and boulders were not surveyed. In other words, sandy areas were selected for this survey and by definition, there are few large rocks in these areas. Stones and boulders exhibit spatial distribution, and therefore can be easily avoided within a larger sand dune or sand sheet. There were few rocks of this size class in all plots and we do not purport that larger rocks control *Uma* distributions in any way. Of the remaining substrate classes, the most significant difference was with the percentage of gravel (5-75mm) in plots. The same is true for cobble (75-250mm). *Uma* prefer areas without gravel or cobble, which do tend to exhibit a random or regular spatial distribution, and thus interfere with locomotion for predator avoidance, subsurface shimmy or sand-swimming. Based on the analyses of biotic and abiotic habitat

characteristics, *Uma* were found to occur in areas with high percentage of sand with few gravel and cobble size rocks and less annual exotic vegetation. These findings are consistent with published literature in terms of preferring primarily sandy substrate.

The results presented here also support the fact that *Uma* do use areas with perennial vegetation, provided the substrate contains appropriate amount of sand. Excessive exotic annual vegetation, to the contrary, is not a component of preferred *Uma* habitat. Although *Uma* are the only North American lizard species known to utilize pure sand sheets as habitat, their range of habitat extends from this extreme to areas with some percentage of perennial cover. It is not known, however, what quality levels can be attributed within this range of habitats, nor is it known for certain how these habitat types are being used by *Uma*. For example, if pure sand dunes are available adjacent to sandy areas with some perennial vegetation, how are these areas, respectively, being used by individuals? Further investigation is warranted to better understand the use of this range of habitat, from pure sand to the composite of sand and perennial vegetation, now that this range has been better defined.

Age observations and implications from temperature data

There was a difference in the ambient air temperature of plots where *Uma* were and were not observed. Temperatures were generally higher in plots where *Uma* were observed, but there was no significant difference in surface temperatures or in the ambient air temperature of plots when surveys were completed. Air temperature plays a greater role in the thermoregulation of these lizards than the surface temperature, at least in the morning as temperatures are warming at the start of the day. Our data indicate that air temperatures were changing more quickly between plots than was surface temperature. However, it is important to note that *Uma* may have occurred in those plots with lower air temperatures, but those individuals were not warm enough to run away and chose a different predator avoidance strategy that did not allow the field crew to identify those individuals. In other words, lizards that are warmer are also faster, to a point, however, lizards that are cold tend to respond more readily to a threat and thus move sooner. Lizards that run away are more easily seen by a human than lizards that remain stationary or that do not move a significant distance. It is also important to recognize that these analyses are not cause and effect, rather, they are correlative and must be interpreted as such. Therefore, these results can be interpreted to indicate that *Uma* are more likely to be seen where median air temperatures are around 31°C and when median temperatures hover around 29°C they are less likely to be spotted.

No significant difference was found in surface temperatures at locations where adults and juveniles were identified. Mean temperatures for both age groups were identical. This provides some evidence that adults and juveniles are operating within the same temperature range. There was no significant difference between subsurface temperatures where adult and juvenile individuals were observed. This is not unexpected, although it is unknown how many, if any, individuals were subsurface. There was a significant difference in the average air temperature where adults and juveniles were observed. Juveniles were, on average, observed at higher air temperatures than adults. The mean air temperature of the "unknown" age group was approximately 3°C. Unknowns comprised 10% of the entire data set.

To determine if time of day may have affected the survey crew's ability to observe individuals, Spearman rank correlations were run on time of day and temperatures. More lizards were seen later in the day. Positive correlations existed between surface and subsurface temperatures and time of day. Overall, *Uma* were observed between 0700 and 1430. This can be interpreted to indicate that the landscape did heat up as the day progressed and that as the land surface became heated so did the subsurface. The warmer the individual lizards are, the more active they become. Hence, as the day progresses and temperatures rise, *Uma* reach a metabolic state that allow them to run quickly. Therefore, it is possible that the field crew were more likely to see individuals as a function of time of day simply due to the metabolic-related activity of individuals as a function of time of day.

Uma density as related to habitat

More *Uma* were observed in areas with highest percentage of sand (see Appendix 2 for additional graphics). Fewer individuals were observed where the substrate contained more annuals, gravel and cobble sized rocks. Overall, the results from correlation analyses are consistent with the other statistical analyses. Not only are certain habitat variables significant to presence or absence of *Uma* but they are also related to observed counts. That is, *Uma* are more likely to be found on sandy areas and the more sandy the area, the more *Uma* there are likely to occur. Similarly, *Uma* were not found to occur with increasing percentages of annual vegetation and there was a strong negative relationship between how many individuals were observed with percent annuals. The greater the amount of annuals in an area, the fewer the number of *Uma*.

The fact that the number of *Uma* observed and the percent perennial cover were not significantly correlated is also consistent with plot level data, but this does not indicate the significance of perennial cover to individuals, as discussed above. In other words, likelihood of observing *Uma* in an area with perennial vegetation the same as in an area without perennial vegetation, but there is no relationship between how many individuals are likely to occur in any area based on perennial vegetation cover. You are just as likely to observe one single individual as you are ten individuals. However, it should be noted that with more vegetation, *Uma* or any lizard species, is more difficult to observe simply due to physical obstruction of view.

What is the role of temperature in *Uma* habitat? It would not make sense to distinguish the temperature differences of plots where *Uma* did and did not occur based solely on temperature because other factors clearly play a role in where *Uma* are found. However, the relative importance of these factors remain unknown. Temperature is a consideration in terms of the probability of seeing an individual, as animals will locate themselves on the surface only during certain temperature ranges. At the plot level, there was a negative relationship between temperature data and ambient air temperature at the start of plot surveys, ranging between 23°C and 39°C. The maximum start and stop air temperature at the plot level was 36°C and 46°C, respectively, and the maximum surface temperature at the start and stop of plot surveys was 46°C and 49°C, respectively. Overall, the temperature rose 10°C during the

actual plot survey. Most individuals in plots were observed between 24°C and 29°C and as air temperatures climbed, fewer *Uma* were observed.

Comparing this to the data collected on individuals during the fall survey, we see that juveniles appear to be more tolerant of higher air temperatures than adults and that adults were observed within a subset range of temperatures as seen for juveniles. This is the only statistically significant difference discernible for individual observational data. While the same relationship appears true for surface and subsurface temperatures, that adults are found within a subset temperature range of juveniles, there is no difference between temperatures on the surface or below surface where adults and juveniles were observed. Due to the differences in numbers of adults versus juveniles, this apparent difference in temperature range merits further study with a more even sample distribution of adults and juveniles.

Landscape perspective using LizLand (Geomorphic Land Features)

Unfortunately, the MAGTFTC DOQ's do not provide coverage beyond the geographic boundaries of MCAGCC. Because a reliable data source was not available for this area with respect to delineating dune features, the LizLand model for adjacent BLM lands do not have the same level of accuracy as for the MCAGCC LizLand model. The majority of the *Uma* observations on BLM appear to fall within less then suitable habitat based on the LizLand model. Better, more accurate delineation of the geomorphology and specifically dune features, would create a more accurate LizLand model for *Uma* on BLM land. However, results from LizLand remain relevant and reliable and are presented here with confidence.

According to the CA-GAP analysis (Figure 28), 99% of MCAGCC is suitable *Uma* habitat and only 1% of MCAGCC is considered unsuitable habitat, suggesting that *Uma* could be found almost anywhere within MCAGCC. Under such cartographic generality MCAGCC would be forced to manage virtually the entire base as suitable habitat for *Uma*, when in fact results from this work indicate otherwise. According to the criteria established by Marcot *et al.* (1983) for validating wildlife-habitat relationship models, the CA-GAP *Uma* model lacks appeal, breadth, depth and validity as well as being neither precise, real, accurate, useful, resolute or whole.

According to the LizLand model (Figure 27), 5% of MCAGCC is considered suitable *Uma* habitat. The LizLand model effectively reduces the amount of necessary manageable suitable *Uma* habitat by 87% (99%-5%). After accounting for that 5%, an additional 42% of the landscape is considered important as sand sources for sand dunes and sand sheets, and for the potential that these areas may hold small isolated patches of undetected suitable habitat. That is, some component of this 5% suitable *Uma* habitat is maintained by these sand sources that exist on MCAGCC. For example, Emerson Dry Lake and the dry lake in Lead Mountain training area are upwind from many locations where *Uma* were found to occur.

These findings are significant for several reasons. First, the LizLand model for *Uma* on MCAGCC supports different scenarios setting aside land to protect and/or preserve *Uma* habitat. Under the LizLand model of habitat definition, suitable habitat is much more refined and, just as importantly, sand sources that contribute to maintaining these habitat areas are

identified and thus can be protected as warranted. Second, using LizLand as guidance, high quality habitat can be identified for conservation and management. The probability that MCAGCC will set aside lands that are not, in fact, suitable *Uma* is reduced. Third, more detailed information provides MCAGCC and other land managers with a better and more accurate picture of the value of their land from a habitat perspective. In this position, all are better able to negotiate (and mitigate) issues related to biodiversity with surrounding land managers and interested stakeholders, all of whom must comply with local, state and federal laws related to rare, sensitive, threatened or endangered species.

CA-GAP greatly over-generalizes the habitat of *Uma*, producing what more resembles a range map than a habitat suitability map. There are significant ramifications of this over-generalization under a scenario of any type of listing of *Uma*, either federal or state. Under the scenario of *Uma* having some federal or state listing, MCAGCC, BLM, and surrounding land managers are left with what may be perceived as an enormous amount of "associated" *Uma* habitat. Using only the CA-GAP map for determining conservation action for *Uma*, the consequence to MCAGCC, as well as the other large DoD military installations in the California Mojave Desert (U.S. Army National Training Center at Ft. Irwin, Edwards Air Force Base and China Lake Naval Air Weapons Station), would be pressure to set aside more land than is warranted, and possibly, setting aside land that is actually unsuitable for the target species. Those lands would thus be removed from training and testing for conservation purposes that may not, in fact, support the desired conservation outcome. Similarly, the consequences of using such a coarse level of cartographic generality make it more difficult for other federal agencies, such as the NPS and BLM, to accomplish their mission of protecting species. It is impossible to select critical habitat for a target species at a resolution below that of a large polygon mapped as uniform habitat. The more difficult it is for the NPS and BLM to accomplish their mandated goal of species protection and preservation, the more difficult it is likewise for the DoD to accomplish their goal of national security due to burden of sole stewardship on one agency's part. Collaborative efforts on all stakeholder fronts would benefit all.

What can be said about predicting *Uma* occurrences?

Accurate predictions are made only when deterministic processes are operating. This means that predictions are made when some set of processes always produce identical results in identical circumstances. For the purposes of predicting *Uma* occurrence, simply understanding the biotic and abiotic habitat variables is not enough to predict with certainty where these animals will occur. The main reason for this statement is that there are other factors that play an important role in presence or absence. First, there must be at least one set of reproducing parent individuals from which new *Uma* may generate and disperse. Second, it must be possible for individuals to survive elements like predation pressure and fluctuations in prey base. Anthropogenic disturbance is a consideration as well and the effects are difficult to effectively capture. Although some effects may be measured within the biotic and abiotic variable measurements, the impacts of human activities on the microscale, such as insect prey base richness and abundance, to the macroscale, such as climate change, are intricate and difficult to effectively capture. Regression does not take into account these variables that are difficult if not impossible to measure, and which are spatial.

In this light, it is not surprising that regression methods did not prove useful in this analysis. Regression analysis looks for dependence between things, in this case between *Uma* and selected habitat variables. The basic question needing an answer by looking at regression analysis in this study was *Is there a linear relationship, a dependence, between Uma and the measured habitat variables?* We assume, in using regression, that the numbers of individuals in an area are dependent on the values of those measured habitat variables. In other words, more *Uma* are expected in better habitat and there is some implication of cause and effect, but clearly more is at play than simply habitat.

None of the diagnostics from regression analyses indicated that a well-fit model could be generated for these data. This is not surprising because most of the assumptions of regression were violated by the inherent nature of the data. These assumptions include constant variance, normally distributed dependent variable, normally distributed residuals, and independence of residuals. Nonetheless, regression is often used as a statistical tool for investigating potential relationships in nature and because it was presented as one analytical option, results are discussed here.

Results from these regression analyses provide little information about the relationships between *Uma* and the landscape because the relationships are non-linear. For example, the R^2 value is a measure of how close predicted values are to observed values. Perfect regression results in an R^2 value of 1 while no relationship whatsoever results in a value of 0. It is often used as the sole indicator of how well the model "fits" the data. Using R^2 value as a measure of goodness-of-fit, the best values presented in this analysis are not high (adjusted R^2 value 0.39). Although it may appear that annuals and perennials were significant variables in terms of modeling *Uma*, as indicated by the reduced model produced with only the two vegetation variables, common sense tells us otherwise. Not every area that has both annual and perennial vegetation can be considered *Uma* habitat. When using regression to make predictions, it is also important to remember that predictions can only be made within the extent of the original data. In other words, not every location falls within the same range as the data analyzed during this study and therefore it would be erroneous to make predictions using this model for other areas. It is clear from other analyses presented in this report that there are significant relationships between abiotic variables such as sandy substrate composition, as discussed above, and *Uma*. To disregard these variables would be to ignore valuable and significant information that does expand our understanding of *Uma* habitat requirements.

This is not to say that *Uma* occurrences cannot be predicted in the probabilistic sense. Given the results of this study we have gained a tremendous amount of information on what comprises *Uma* habitat in and around MCAGCC. Predictions can be made based on the LizLand model and further refined using vegetation and surface composition surveys. From a management perspective, the question is not are there *Uma* at a specific location, rather, the question is, is this suitable habitat that may be important to *Uma* on MCAGCC? The difference in these two questions is critical. The only way to know for certain that any species occurs for certain at any location is to survey for that species at that location. This is why all federal, state, and local agencies charged with managing or monitoring species (i.e.

US Fish and Wildlife Service or state level fish and wildlife or fish and game departments) include surveys as the basis for their management protocol. Those agencies that do not manage specifically for wildlife species but rather manage habitat, such as the US Forest Service or the Bureau of Land Management, may or may not include wildlife surveys. Typically agencies managing habitat work in conjunction with agencies that manage wildlife. Military installations manage both for wildlife and for wildlife habitat, which requires an understanding of both the wildlife biology and the wildlife-habitat interactions. Understanding both the geographic distribution and life requirements of *Uma* individuals, populations, and metapopulations has equal importance for managing and maintaining suitable habitat.

The fact that Maumee Mine, for example, was surveyed and found to have neither individual *Uma* nor apparently suitable habitat, is useful information to the NREA in its management and coordination with training and testing operations. Not only was the only potential habitat surveyed and found not to be appropriate habitat at all, but the geographically nearest *Uma* population located was 17.5km away on Emerson Lake RTA. If suitable habitat had been located in Maumee Mine RTA but no *Uma* were observed, further investigation might have been warranted to find out why no *Uma* occurred there. To give a concrete example of this situation, consider Quackenbush RTA. *Uma* were identified there by Cutler *et al.* in 1999. In our 2001 survey of the same sand sheet, no *Uma* were identified in any of four plots. Two of the plots were considered to be typical *Uma* habitat, being between 98 and 100% soft sand. The other two plots had similar characteristics but were considered medium packed sand, rather than loose sand. One plot was located in a wash. This begs the question, do *Uma* still occur at this location and if not, why not? In one case, the 2001 plots are located less than 0.5km from the location where the original sightings were made in 1997. Within dune features, particularly sand sheets, the environment may be described as hummocky, where there is a high degree of heterogeneity within a given area. That is, pockets of suitable and unsuitable habitat exist within the greater defined suitable dune habitat feature. Within this heterogeneous matrix of soft sand and hard packed sand, *Uma* would of course only be found to occur in the soft sand under suitable conditions. In this scenario, it is possible that *Uma* do occur in the greater dune, but were not found to occur within sampled plots. The other possible explanation is that *Uma* no longer occur at that location. Where small, isolated populations of habitat-restricted species exist it is not uncommon for temporary extinctions to occur with population reestablishment later. This is a cyclical phenomenon, where extinction and reestablishment occur repeatedly over time. This is one possible explanation for the documented presence of *Uma* in 1997, but apparent absence in 2001, where the last few individuals were identified in 1997. Now, in 2001, in is possible that the population is in a state of local extinction. The nearest known populations that would support reintroduction are Emerson Lake and Gypsum Ridge.

It is also possible, that individuals occur on Range Range, which was not surveyed for safety reasons. This brings forth a management issue for MCAGCC officials, namely, if there is local extinction of *Uma* at this location, do avenues exist to allow the natural cycle of extinction-reestablishment to continue? That is, are there sufficiently close populations that can support reestablishment and are these populations suitably maintained?

Similarly, in 1990 Minnich *et al.* identified an *Uma* just to the west of Mainside on BLM land. Again, four plots in the vicinity (less than 1km from the original sighting in 1990) yielded no individuals. In fact, the sand at that location was found to be consistently hard packed and was not considered, upon visitation, suitable habitat. Three plots on BLM land immediately adjacent to Acorn TA yielded no *Uma*. One of the plots may have been marginal habitat, consisting of soft substrate, but with an estimated 13% cover of annuals and a mix of gravel and sand. Again, the heterogeneous matrix of soft and hard packed sand within a sand sheet feature plays a role in the distribution of individual within a population and potentially in the distribution of metapopulations as well. Emerson Lake is another good example of the relationship between pockets of habitat and non-habitat within a larger identified dune feature and the distribution of *Uma* individuals. Here, 63 individuals were observed between 1983 and 1998 and an additional 15 were observed during this 2001 survey. Six plots were surveyed in 2001 but only one plot yielded positive results for *Uma*. One plot, located 138m from a location where 31 individuals were observed in 1983, was found to be hard packed sand and not considered suitable habitat. It is unknown whether the state of the substrate has changed in the past 18 years and in 1983 *was* soft sand but is now hard pack or if this location has always been in its present state. Given the dynamic nature of the sand systems, it is unlikely that any area can be considered static over time. Although other plots were found to be suitable habitat for *Uma* but were not found to contain individuals, the field crew reported identifying individuals outside plot boundaries in the immediate area. Again, this illustrates the fact that habitat variables alone cannot be predictive for wildlife. There must be some factor(s) other than those measured, or those that can be quantified, that act in location selection at the individual level.

What is clear is that to maintain existing *Uma* populations, more area than just the locally suitable habitat must be identified for management. Suitable habitat exists within a matrix of heterogeneous conditions such as hummocks or pockets of soft sand with few annual species interspersed with hard packed sand and less suitable levels of vegetation and vegetation composition. Clearly individuals are moving within this matrix of suitable and unsuitable habitat throughout the greater identified dune feature. In fact the idea of labeling hard packed sand as unsuitable habitat may be in error. Hard packed sand interspersed with soft sand may serve a different purpose altogether, and as such is not unsuitable, but rather serves a specified purpose for *Uma* at the population level. What that purpose may be is unknown. *Uma* were found, for example, in what was termed medium-pack sand in Lead Mountain during the 2001 survey. Individuals were also identified in nearby areas in 1996, 1997, and 1998. One individual *Uma* observed in 2001 was noted to have "left a soft sandy spot" within the medium packed sand of the survey plot and traveled through more firmly pack sand. From a practical perspective, the scale at which this matrix occurs prohibits specialized protection of tightly defined *Uma* habitat. Clearly, *Uma* occur within a range of habitat extent from homogeneous classically defined soft sand to very heterogeneous patchworks of mixed sand compaction.

Habitat comparison between BLM and MCAGCC

Three locations were found to have *Uma* on BLM land. Two areas, Spy Mountain and Cleghorn wilderness, were not found to have *Uma* or potential *Uma* habitat. This indicates

that there is suitable habitat adjacent to MCAGCC that support *Uma* populations. Some locations on BLM land were found to harbor *Uma* in the past, but were not found to have individuals during this survey. For reasons described in the previous section, this may be a function of local extinction (temporary), of actual extinction (permanent) due to habitat loss or alteration, or due to the location of survey plots within a matrix of heterogeneous landscape conditions.

What can be said about BLM *Uma* habitat is that where *Uma* were found outside MCAGCC boundaries in this survey, habitat conditions could be considered "good" to "excellent". At the same time there is less habitat on BLM lands from a cumulative area measure. In other words, there is good quality habitat on BLM land confined to very specific areas. These areas vary in size from rather extensive, as on Copper Mountain, to highly contained, as in Valley Mountain and Bristol Mountain.

Bristol Mountain is perhaps the most remote location found to harbor *Uma*. At one site *Uma* were found to occur on a climbing/falling dune (Figure 30) with no annuals, 6% perennial cover, and a mix of soft, loose sand and large stones. Similarly, the second Bristol Mountain Similarly, the second Bristol Mountain site had no annual vegetation, 6% perennial cover, and was 98% soft loose sand. This second site, situated close to a pipeline and a power line maintenance road, was located in an area otherwise characterized as "pristine", indicating little evidence of human activities in the form of vehicular tracks, litter, or graffiti. Given the predominant winds in the southern Mojave, source sand feeding these dune features are outside of MCAGCC.

Copper Mountain, where more than 50 *Uma* were documented, also had very low annual vegetation cover. Only half of the plots in this area had annuals, and this was only 1%. Perennial vegetation ranged between 3 and 7 percent. This area is almost entirely loose, soft sand and what is notable is the proximity of urban/suburban development to this area. Two plots were noted to have vehicular tracks and one plot contained a lot of trash. Most of the individuals observed were juveniles, which may have been a function of the timing of the survey (mid to late September).

Figure 31 shows the location of the plots where *Uma* were found at Copper Mountain and also identifies those plots found to have annual vegetation. If these annual species are exotics, it would be of interest to investigate the spread of these exotics with off-road vehicle or other recreation in this area. Two elements are of concern to the *Uma* in the Copper Mountain area. The first is source sand that maintains the dune habitat. Upwind of this area, development is occurring, converting landscape that provides Aeolian sand to hardened surface, incapable of blowing away. Second, it is unknown the exact effects of OHV activities on either the sand substrate or *Uma*. Certainly, vehicular recreation serves to break up surface crusts, but loose sand can be maintained only where the hard pack does not extend beyond the depth to which heavy vehicles can take effect. Furthermore, certain types of OHV activities are targeted to dune and soft substrate areas. Again, the extent to which those activities perpetuate the state of loose sand is unknown. Neither is the effect known of OHV activities on increasing sand losses from aeolian transport. The effect of the physical presence of OHVs or humans on *Uma* in terms of disturbance, prey reduction, interference

with reproduction, or foraging is being partially addressed by Dr. Dave Morafka in the El Mirage Dry Lake, Rasor Road and Dumont Dunes OHV areas (Morafka, pers. comm.).

Figure 30. Representation of Bristol Mountain site on BLM land. Plot in pink with Uma observations as green dots. Data overlaid on USGS 1:24k topographic maps.

Two plots in the Valley Mountain area were surveyed. Six *Uma* were identified in one plot characterized as "good dune habitat; undisturbed". This plot was primarily loose sand (96%) with a few stones (4%), 2% each of annual and perennial vegetation. In the plot where *Uma* were not found no perennials occurred but habitat variables were otherwise nearly identical. The two plots were less than 0.5km apart and habitat conditions were very similar. There is a 4x4 road indicated on topographic maps to the east of these plots, but this area is relatively undisturbed especially when compared to Copper Mountain or heavily used training areas on MCAGCC.

On MCAGCC, plots where *Uma* were observed ranged between zero and seven percent annual vegetation cover and between 63 and 100% sand substrate. In general plots were considered by the field crew to be good dune habitat. Some plots where *Uma* were identified

were noted to be a mix of compacted sand (soft and hard). Tank tracks were noted in plots where *Uma* were observed in Acorn, Gypsum Ridge, and Emerson Lake training areas. The extent of annual invasion throughout MCAGCC was not part of this survey, but some information may be useful to NREA for management and monitoring purposes. For example, Figure 32 depicts percent coverage of annuals in eight plots surveyed on Emerson Lake. Each plot is color-coded according to the percent annual (exotic) coverage, ranging from lowest (green) to highest (red).

Annual coverage for the entire survey area is as high as an estimated 12%. Maumee Mine plots, located on the westernmost border of Maumee Mine TA also had relatively high percentage of annuals (7%). Likewise, the same pattern is seen in Lead Mountain, where plots are even more remote to concentrated human activities such as Mainside. Compare these to plots in Lavic Lake, shown in Figure 33, where the highest cover of annuals was an estimated 5%. Although close to vectors of spread, (i.e., roads) highest concentrations of annual vegetation does not appear to be directly related to distance to road. Figure 34, depicting percent cover of annuals immediately adjacent to Mainside, demonstrates that a direct relationship between roads and annual vegetation may not be straightforward. What is apparent is that plots on Acorn, Emerson Lake, and on adjacent BLM land, had highest percentages of exotic annuals.

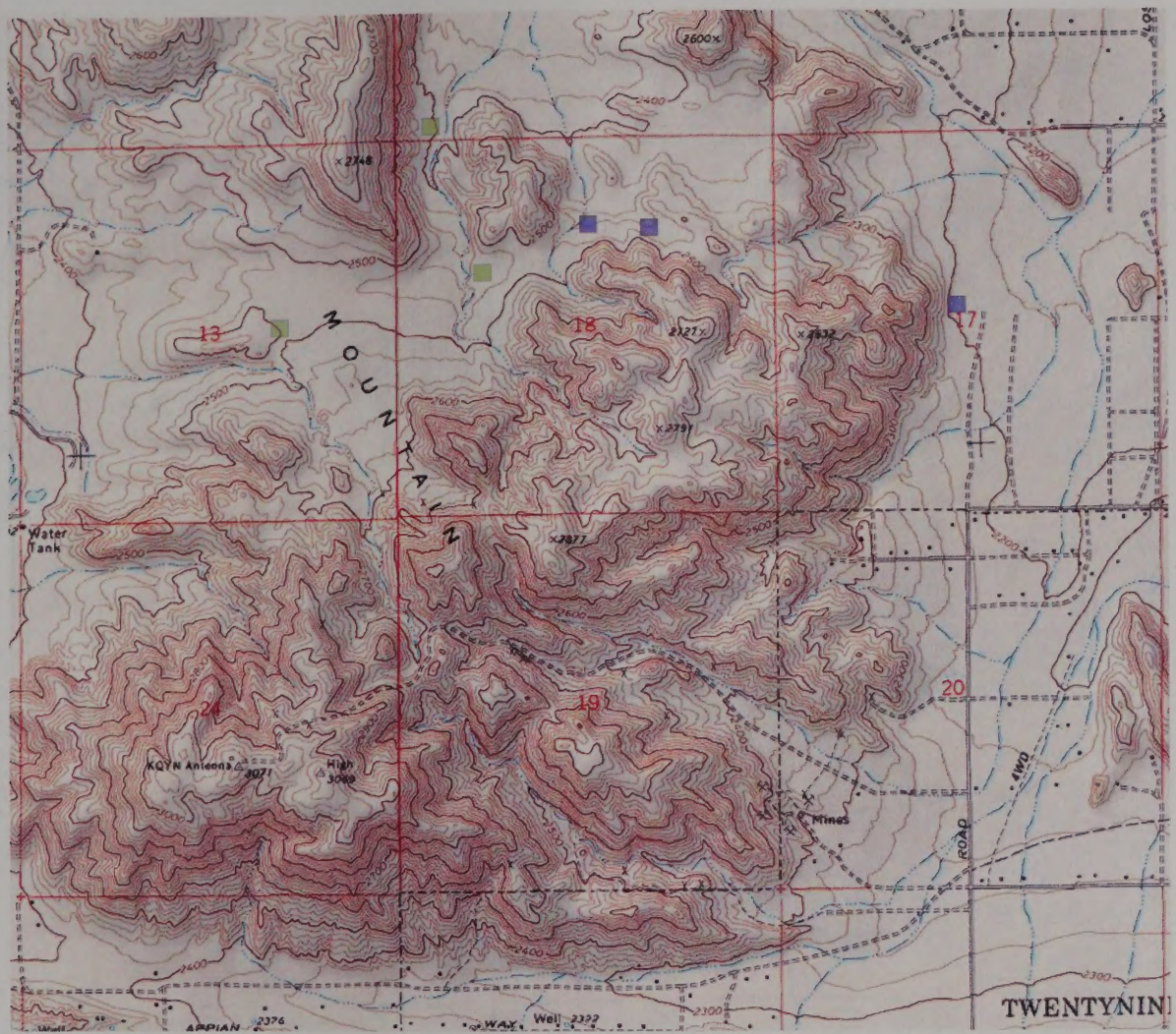


Figure 31. Plot location at Copper Mountain overlaid on 1:24k USGS topographic map. Purple plots were found to have annual vegetation (exotics) while green plots had no annual vegetation (exotics).

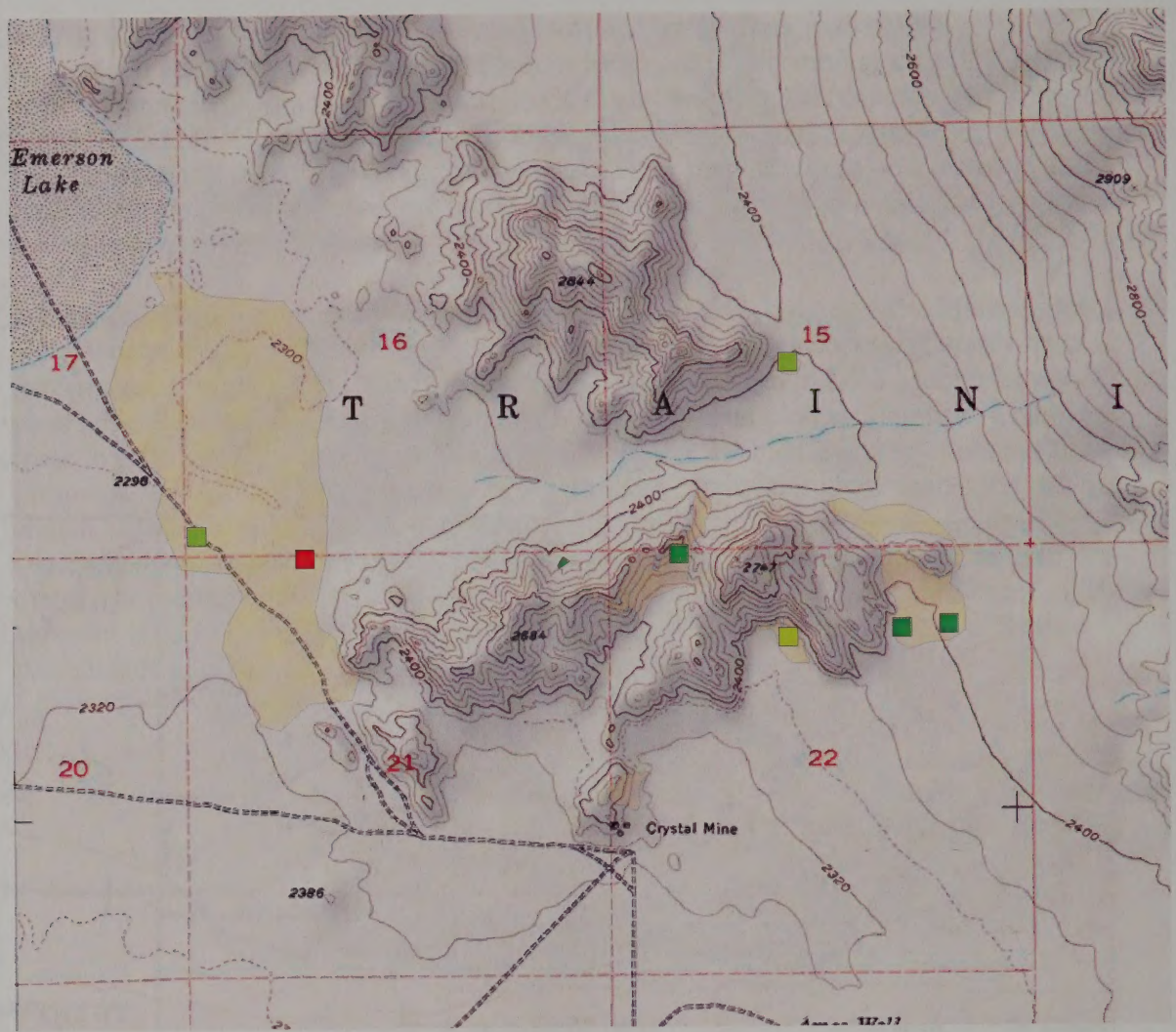


Figure 32. Example plots surveyed on Emerson Lake color-coded by the percent annual (exotic) vegetation. Green plots are lowest percent, yellow are mid-level, and red is highest percent. Dune features are shown in tan and data are overlaid on USGS 1:24k topographic maps.

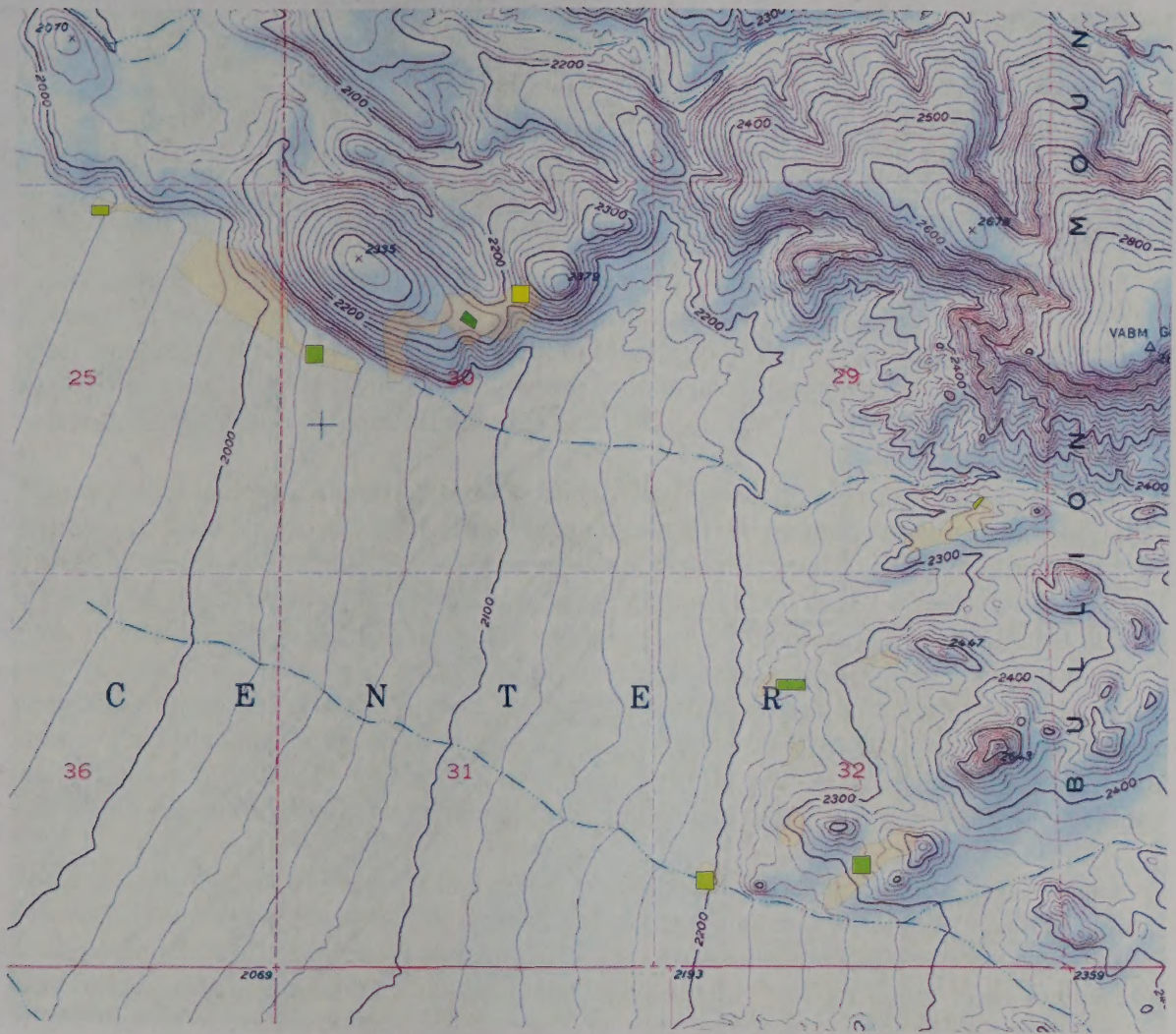


Figure 33. Representative plots in Lavic Lake mapped percent annual (exotic) coverage by color. Greens are lowest percent and yellow is highest percent relative to the entire database. Dune features are shown in tan and data are overlaid on USGS 1:24k topographic maps.

Figure 34. Example plots surveyed near Mainside, color-coded by the percent annual (exotic) vegetation. Green plots are lowest percent, yellow are mid-level, and red is highest percent. Dune features are shown in tan and data are overlaid on USGS 1:24k topographic maps. Dark shading at the top of this figure is due to quality of digital topographic map.

Management Recommendations

Based upon the findings of this study and that of Cutler *et al.* (1999) we provide management recommendations that fall within three main categories:

1. Strengthen the coordination, data sharing, and joint research efforts with neighboring land management agencies who have species protection mandates;

2. Preservation of a maximum amount of habitat within RTAs that receive minimal use or areas that receive minimal use and are a subset area within heavily trained RTAs;

3. Preservation of a minimal amount of habitat within heavily trained RTAs.

Without question the most effective and long-term solution for maintaining viable populations of *Uma*, under the threat of potential federal or state listing, that the MAGTFTC could pursue is to encourage and collaborate with the BLM to aggressively and actively manage the Copper Mountain and Copper Mountain vicinity lands for *Uma* populations and habitat. *Uma* were not reported to occur at this location before this study, but it is now clear that there is a population of *Uma* at Copper Mountain and there is heavy use of the area by OHV and similar recreation types. These Copper Mountain vicinity lands hold dual importance for the BLM, as this area has been recommended by BLM staff as potential desert tortoise "reserve" habitat (LaRue, pers. comm.). The desert tortoise was listed as a federally threatened species in 1990. This area also contained the largest number of *Uma* observed during our study at any one location. More importantly, perhaps, is the finding that those *Uma* were found to be by overwhelming counts, juveniles, suggests that this area may be a source population (in contrast to a sink).

The two other locations identified as supporting *Uma*, appear at this time to receive low-level disturbance from human activities. The habitat appears to be in good condition, although the Valley Mountain site exhibited low levels of exotic annual vegetation. This relatively undisturbed state should be maintained and we recommend that the BLM monitor these two sites for *Uma* at a frequency that reflects expanding use of remote areas by people. At this point in time, these areas have low use but as development pressure continues and as more people move into and visit the Mojave, the condition of the Bristol and Valley Mountain sites is expected is decline. Periodic visitation, such as annually, by BLM officials to each of these two sites to record disturbance in terms of amount of trash, vehicle tracks, footprints, graffiti, and exotic vegetation should be sufficient to indicate when degradation of these sites begins.

There is some evidence to suggest that exotic vegetation is invading the Copper Mountain area and if true, this spread could be detrimental to both *Uma* and tortoise populations. The same potential threat of spread is true for the Valley Mountain site and on public land due west of Mainside in the hummocks due west of the Sewage Treatment Ponds (see Figure 34). Highest levels of exotics outside of MCAGCC boundaries were identified less than 200m from Acorn RTA boundary. Densest coverage of exotics within the installation were found on Emerson Lake and relatively high percentages were also recorded in Lavic Lake plots. The pattern of spread appears to be along the north-south axis, although no concrete statements can be made because spread of exotics was not a component of this study. However, taken as preliminary evidence of a potentially significant problem, both economically and ecologically, we recommend some effort be taken to identify the mechanism of transport and level of threat of exotic species, particularly *Salsola spp.* and *Schismus*.

Another area for potential collaboration with MCAGCC and BLM is with Joshua Tree National Park (JOTR). JOTR acquired a significant amount of potential *Uma* habitat in the northeast area of the park with passage of the 1994 California Desert Protection Act. No *Uma* locations have been officially documented within Joshua Tree National Park, although the park does list it as a species that is "known" to occur within the park. Currently a reptile inventory project is being conducted within the park, however it remains questionable as to

whether or not potential *Uma* habitat is included in the survey for sampling (Rodgers, pers. comm.).

With the understanding that training intensity, frequency, and location change continually, it is critical to maintain existing populations of *Uma* within installation boundaries. In addition to encouraging and supporting the protection of *Uma* and its habitat within the BLM Copper Mountain lands, we recommend preserving the maximum allowable amount of habitat within minimally trained RTAs. We identify these RTAs to be Mainside, East, Prospect, Acorn, and/or areas that see minimal amount of training activity such as the small isolated climbing dunes in Lavic Lake that border the Bullion Mountains, the sediment hills of Gypsum Ridge and Quackenbush, and the dunes along Deadman Dry Lake. Some of these specified areas harbor *Uma* and some areas are believed to contribute source sand.

Prospect may be considered a heavily trained area, however, the type of training does not involve activities which would impact the locations where *Uma* were found to occur. This area is remote and not accessible with surface vehicle, only on foot or via helicopter. *Uma* were not found to occur in Mainside but suitable habitat does exist and *Uma* are known to occur in extremely close proximity to that suitable habitat, on East RTA. Mainside is therefore included in this recommendation. Protection in Mainside and East RTA would include maintaining habitat that is free of human disturbance such as trash and also monitoring ecological condition of exotics. The proximity of *Uma* habitat and known locations to development in Mainside is both positive and negative. No heavy vehicle traffic occurs here, but this area is easily accessible by people. The areas cited above provide maximum trade-off between species protection and military mission priorities. Protecting these areas may contribute to species protection with minimal amounts of conflict with military training mission. As training requirements change, we recommend avoiding training in these specified areas as much as possible.

We recommend MAGTFTC set aside a minimal amount of area within heavily trained RTA's such as Emerson Lake and Lead Mountain, with the exception of at least one climbing/falling dune complex (dune #53, 4 digit grid ~5909) within Emerson Lake (Figure 35). This dune is suited for protection due to its isolation, relative vehicle access difficulty, and the large number of *Uma* observed there. These areas provide minimal trade-off between species protection and continued military mission. Recent surveys (ours and Cutler, *et al.* 1999) suggest that *Uma* populations are stable within these areas. As long as military training activities do not change in intensity, frequency, duration, or type, we so no reason to expend a large amount of management effort protecting *Uma* and their habitat within these areas other than to reduce the amounts of exotic vegetation if and where. However, in choosing to not protect habitat, we recommend that MAGTFTC commit to a monitoring program, targeting the same areas as sampled by Cablk and Heaton (2001) and Cutler, *et al.* (1999). This will help ensure that the stability of these populations can maintained through early indication of change through monitoring. If and when populations begin to decline, this management recommendation will need to be revisited.

Given the results of work within Lead Mountain, it seems most appropriate to consider protecting the areas where Cutler *et al.* (1999) and Cablk and Heaton (2001) found high numbers of *Uma*, particularly in the vicinity of the six-digit grid 004230. Figure 36 depicts

that location including the great matrix of dune feature that is comprised of hummocks with varying levels of compacted sand. Two roads traverse this specific location, where *Uma* were found to occur. Protection for this specific location could include prohibiting travel off the established "road" and prohibiting associated foot traffic involved in training exercises.

Figure 35. Dune suggested for protection in Emerson Lake RTA, circled in black, approximate grid 5909. Purple dots indicate *Uma* sightings between 1983 and 2001.

Suggestions for Further Study

There are many questions that inevitably arise from studies, especially from studies with the breadth and depth of this one. Some questions arise from literature-based protocol. For example, it is known that temperature plays an important role in the activity of *Uma* and there are published temperature ranges that were used to set survey limitations to maximize efficiency. However, the field crews were not satisfied with the temperature ranges restrictions, as they consistently observed *Uma* out in cooler weather than previous studies have indicated as they were en route to sites or as they were waiting for temperatures to reach the lower range value. This may be due to a combination of higher surface temperatures that negate the cooler air, or a function of the size of the *Uma*, as the field crew observed that

smaller *Uma* were more likely to be out in the cooler temperatures. Further studies into the temperature range of *Uma*, the differences in temperature requirements for adults vs. juveniles, and the temperature differences between adults and juveniles going into torpor may be suggested.

Many additional research questions arise from anecdotal accounts and experience while conducting surveys. For example, during the fall survey of plots, the field crew reported they often found a large number of juveniles and only a few adults. This reported relative proportion is not an unusual phenomenon, as typically juvenile *Uma* out-number adults later in the year, as more and more clutches are successfully hatched. In other words, the observed

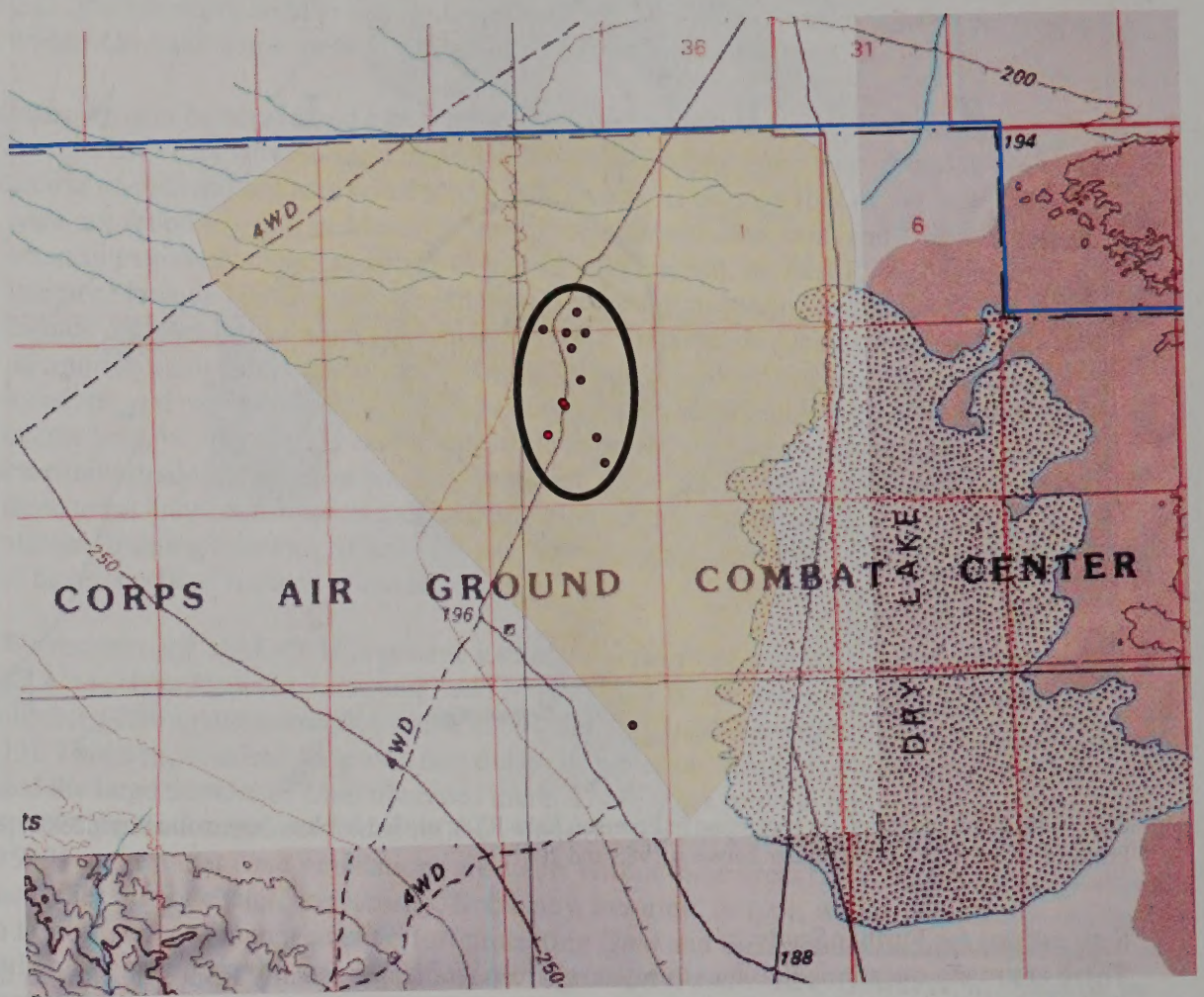


Figure 36. Recommended area for protection in Lead Mountain where Uma were located repeatedly in the past decade, designated in black oval. Purple dots indicate pre-2001 sightings, red dots are 2001 survey sightings. Dune feature overlaid on USGS 1:24k topographic map. Variations in color are due to quality of digital topographic map. MCAGCC boundary indicated by blue line.

high numbers of juveniles probably relates to the fact that clutches are hatching and there are, in fact, more juveniles than adults. There is a time lag between hatching and survival. However, this observation also brings into question relationships between environmental

factors and successful clutches. Further studies into the correlation between seasonal and annual precipitation with clutch size, nest success, juvenile survivorship and dispersal would not only add to our knowledge of the Mojave fringe-toed lizard, but possibly help in determining population status and trends.

In the process of locating *Uma* in geographically very small areas, with no surrounding dunes, questions regarding genetic diversity of populations and metapopulations become obvious. The use of hummock habitat, and what might be described as marginal medium-packed sand may increase the individual genetic exchange between populations. Graduate student Tanya Trépanier (University of Toronto) is currently working towards identifying and understanding the genetic diversity and biogeography of *Uma spp* under the advisement of Dr. Robert Murphy and Dr. Dave Morafka. Presently, her efforts do not include animals taken from MCAGCC. However, we are working with Dr. Morafka to attempt to obtain samples and develop joint research projects between the MAGTFTC and the National Training Center at Fort Irwin to include MCAGCC animals. Results from this type of work that would include genetic material from individuals on MCAGCC would answer some of the questions regarding population stability from a genetic perspective and would support investigation of population stability from an ecological perspective. Furthermore, it would provide insight into the idea that local extinction with later re-establishment of small populations is or does occur on MCAGCC.

From a biodiversity perspective, it would be interesting to determine what, if any, relationship exists between *Uma* and other flagship species, such as the desert tortoise. In the Copper Mountain area, which has been recommended for protection for desert tortoise, protection of those lands may also benefit *Uma*. How tightly these two species are linked is not well understood and if conservation efforts for one species will benefit the other, then management efforts may provide better coverage in terms of species protection.

And finally, we recommend the continued development of the LizLand model for identifying and predicting *Uma* habitat within, but primarily outside the boundaries of MCAGCC. Currently, the BLM is supporting LizLand model development through a grant to Dr. Dave Morafka in the El Mirage Dry Lake OHV area. There may be opportunities for joint collaboration between the BLM and the MAGTFTC.

Acknowledgements

We would like to thank several people for their contribution towards this work, particularly Mr. Rhys Evans of the Natural Resources Environmental Affairs Division (NREA). Mr. Evans was instrumental in providing support, guidance, and access at all levels of this research. It was because of his vision and foresight that this project was conducted. We thank John Montoya, Jody Fix and Captain Travis Sutton in the contracting office and DRI business manager Linda Piehl. MCAGTFTC staff Brent Husung, Paul (Kip) Otis-Diehl and Lorrie Agnew provided data and support, particularly with scheduling access during field data collection. Three field crew members were outstanding in their tasks collecting data under difficult conditions: Justin Neviakas, Megan Kornbluth, and Angela Rex. We commend them for their tireless efforts and valuable contribution to this project. There are many other MCAGTFTC staff who assisted at various times of need during this project that we wish to acknowledge in spirit. Mr. Tom Egan was instrumental in formulating this work at its conception as BLM representative. Finally, Ayoko Ochi and Tanja Kohls contributed graphics.

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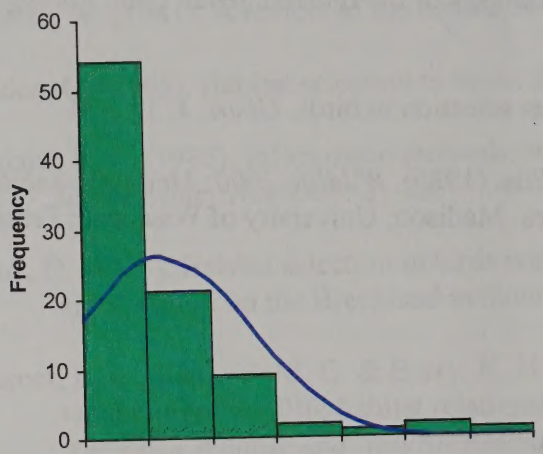
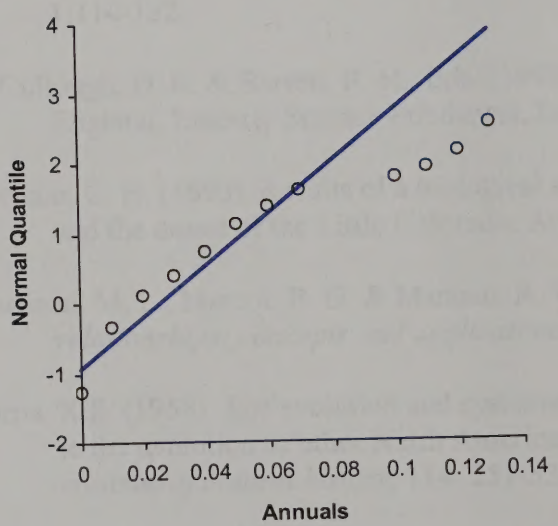
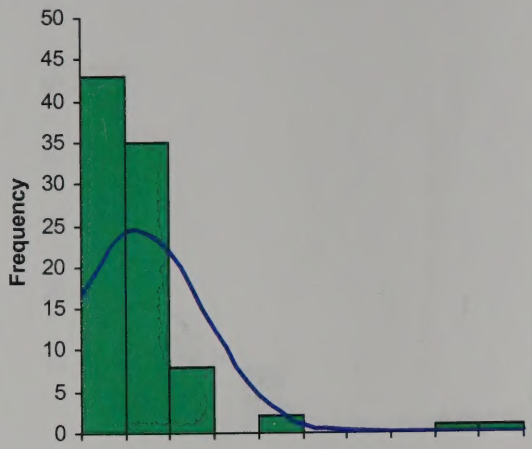
APPENDIX 1.
Frequency histograms and normal plots for habitat variables used to determine normal distribution.

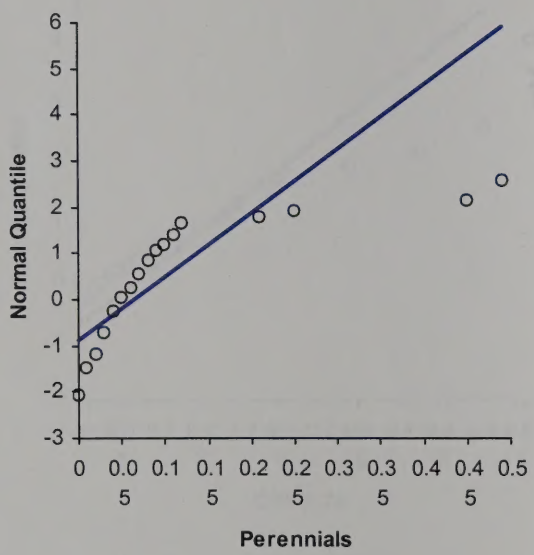
Percent cover of annuals:



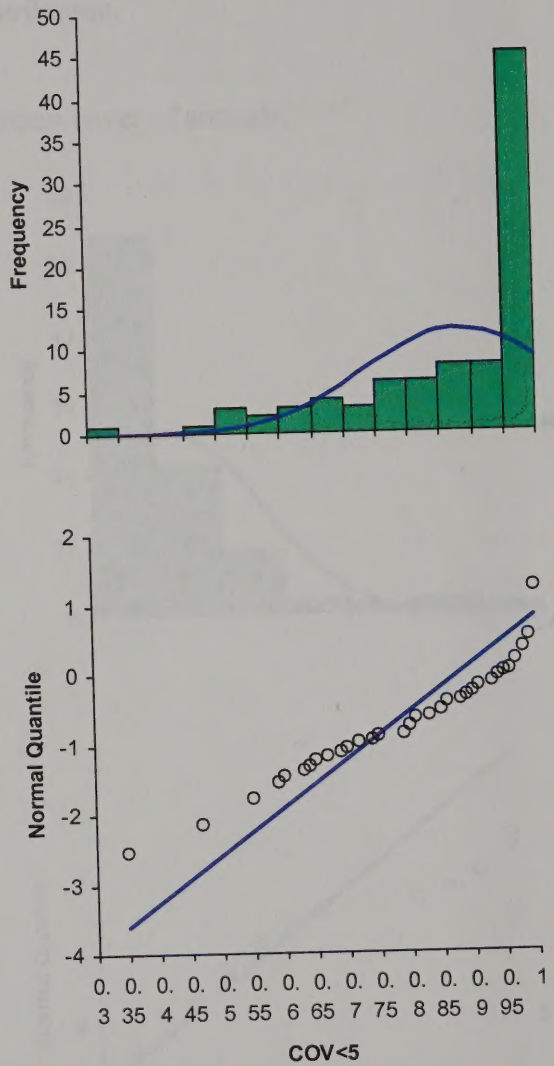


Percent cover perennials:

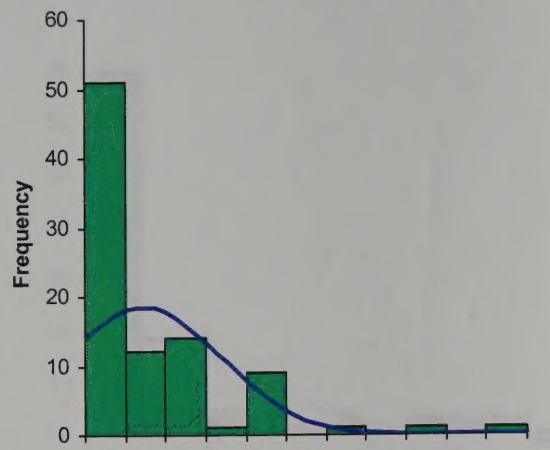


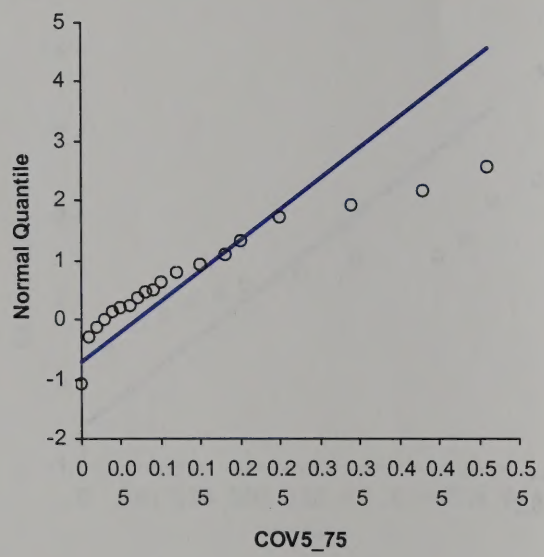


Percent cover sand (< 5mm):

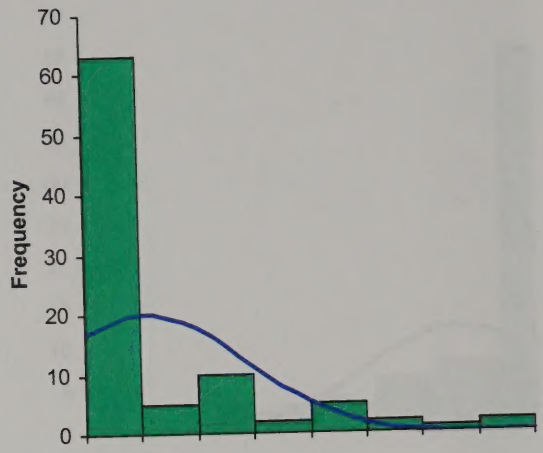


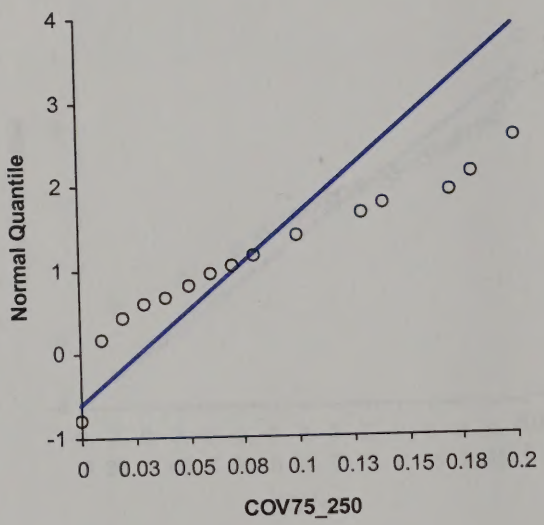
Percent cover particles 5-75mm:





Percent cover particles 75-250mm:





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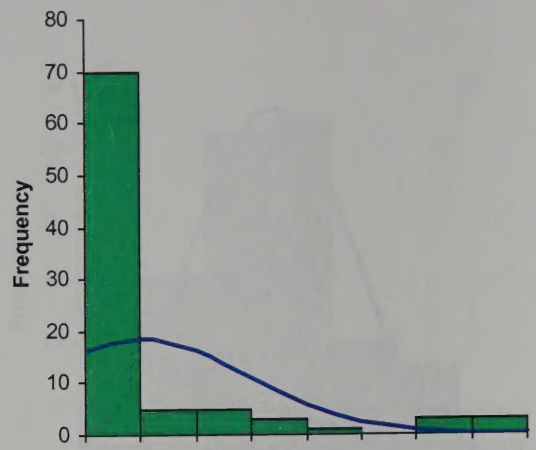
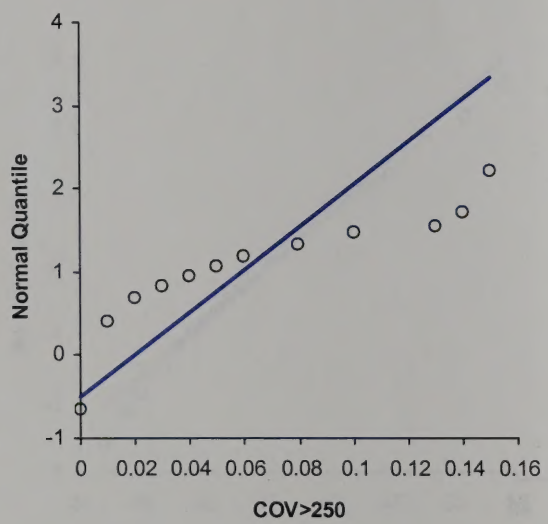
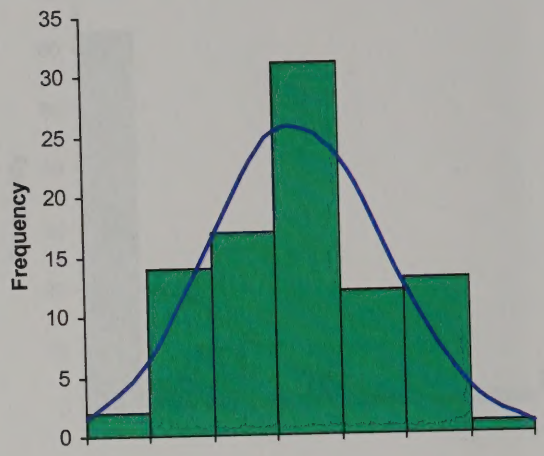
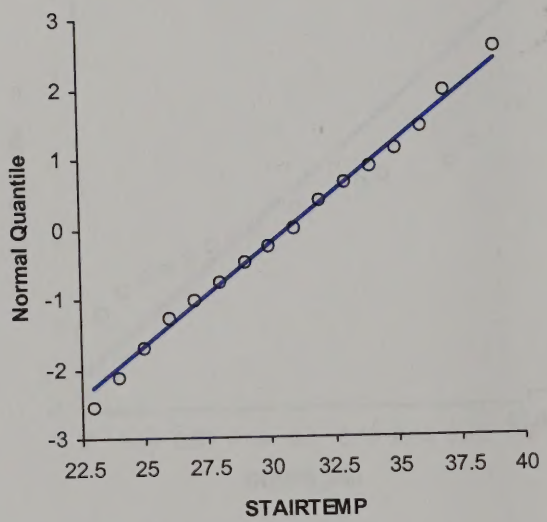


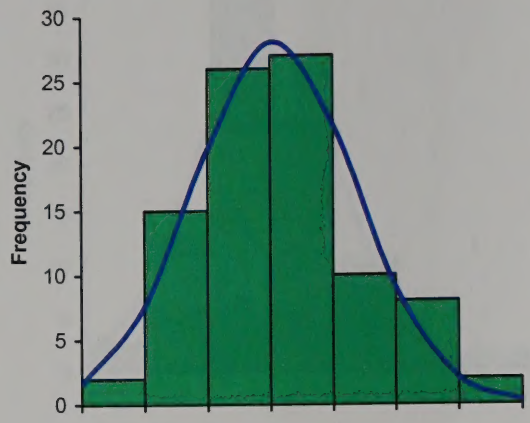


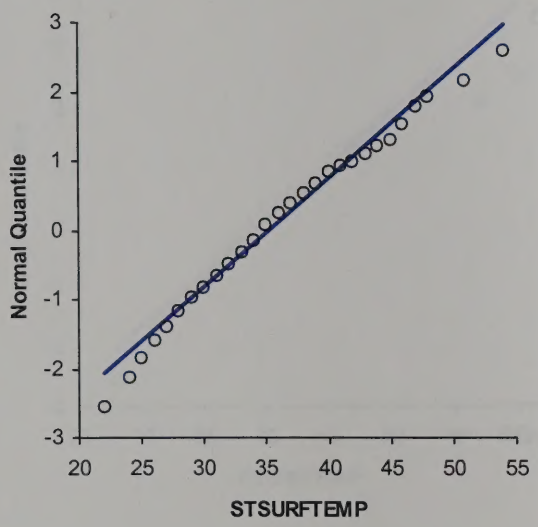
Ambient air temperature at start of surveys:





Surface temperature at start of surveys:





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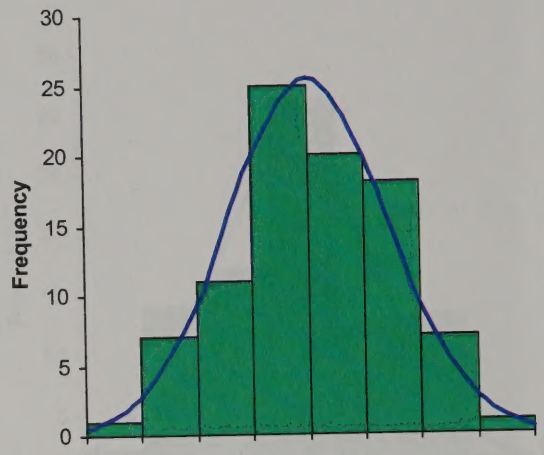

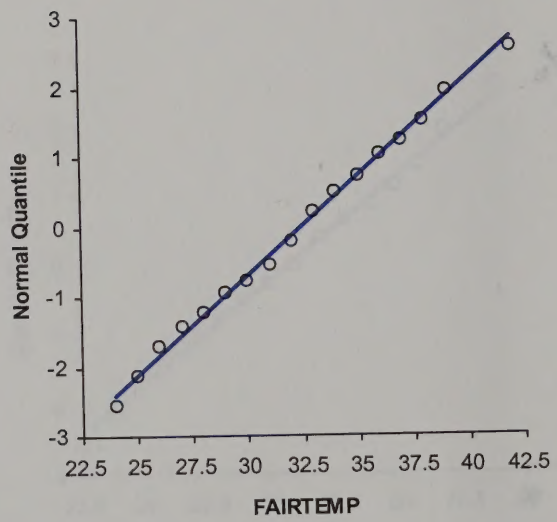

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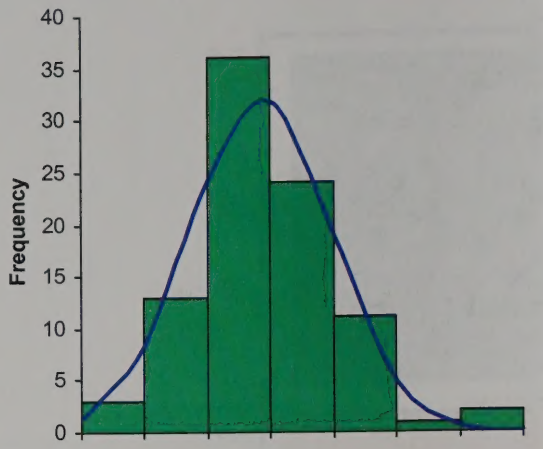
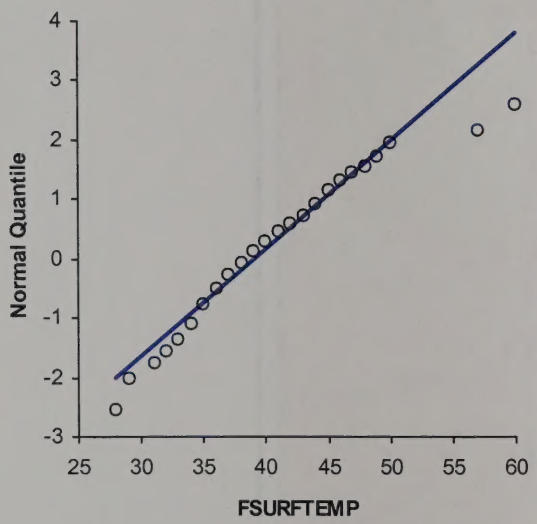
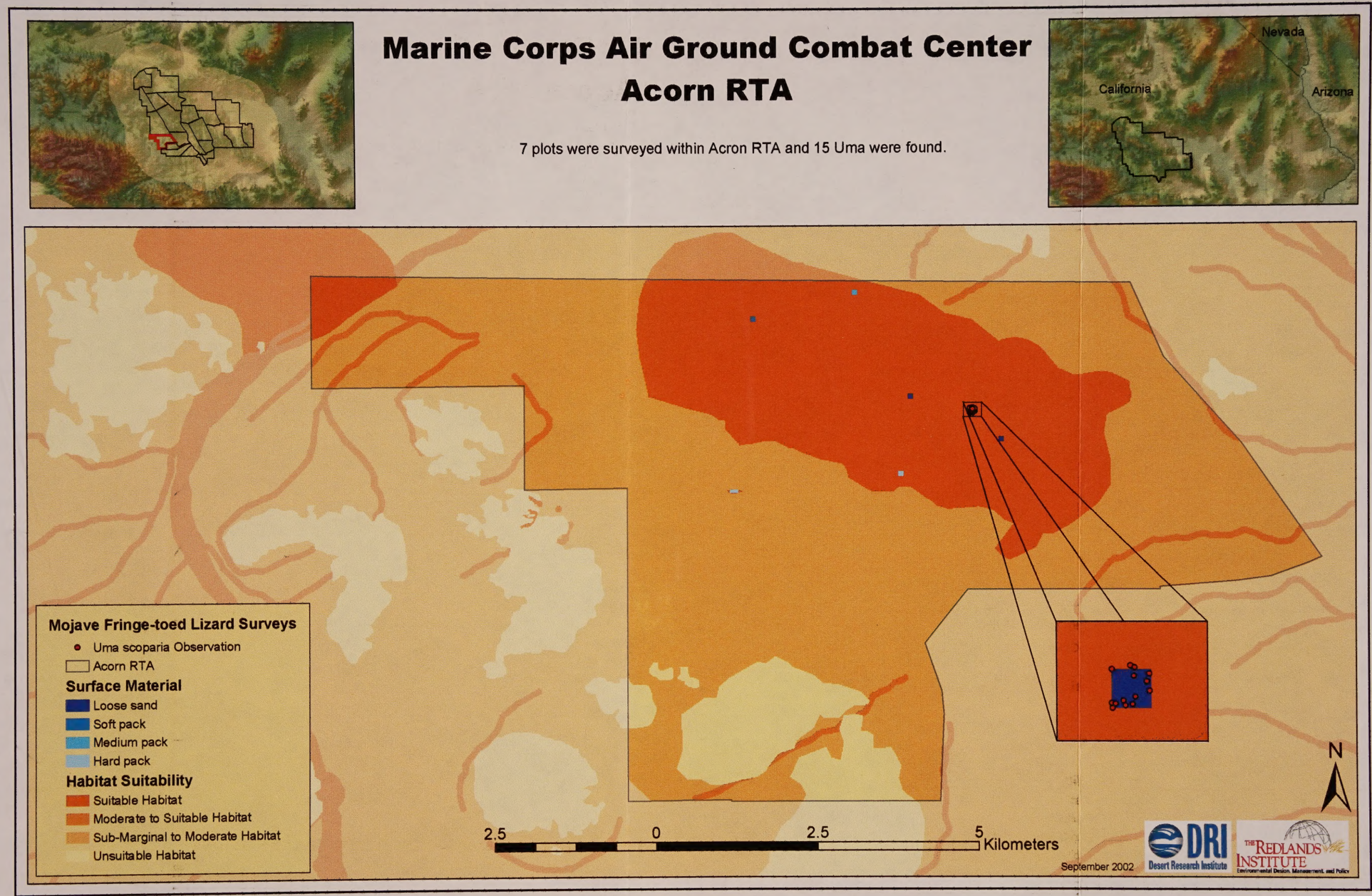




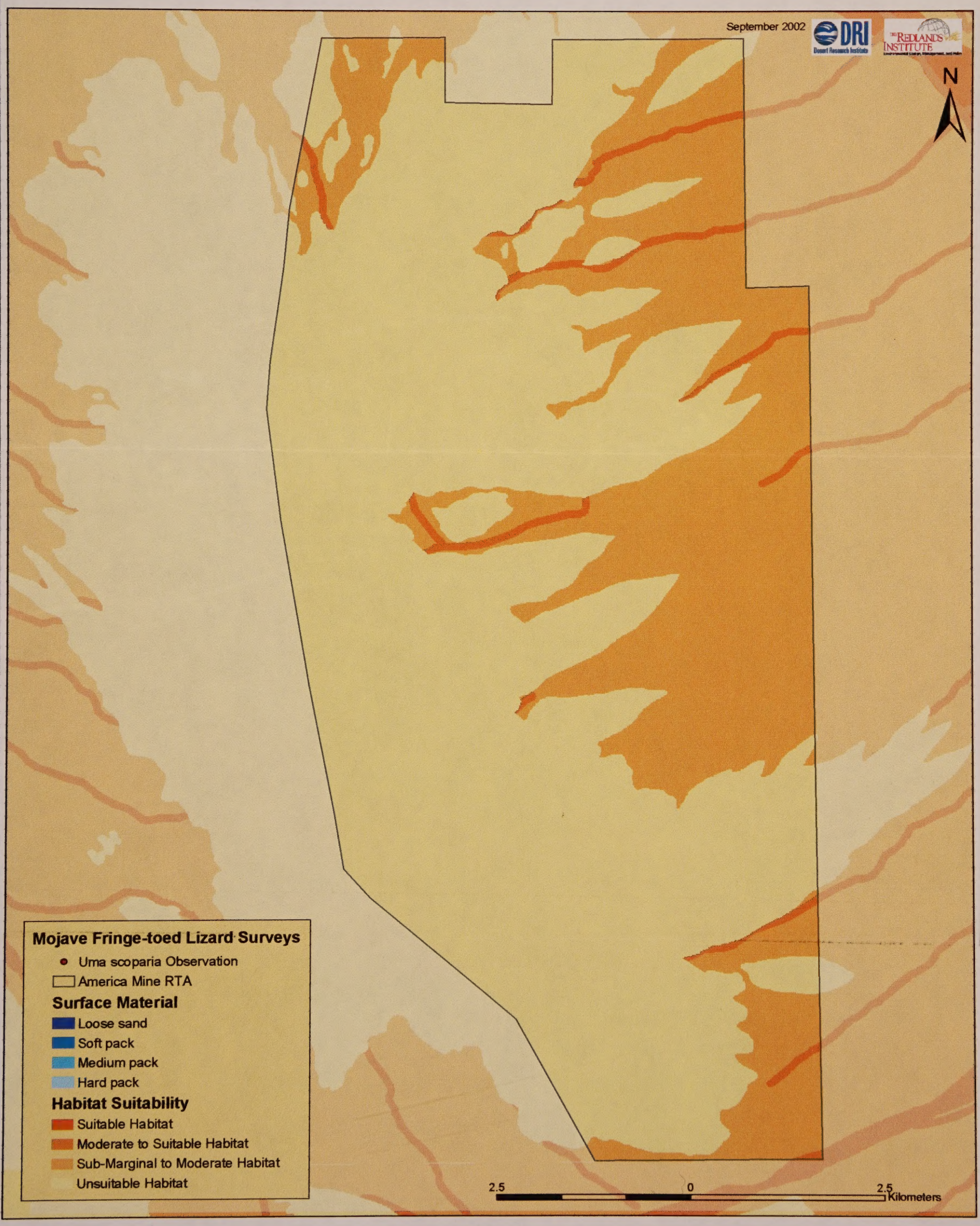
APPENDIX 2.
LizLand Model by RTA for each RTA.

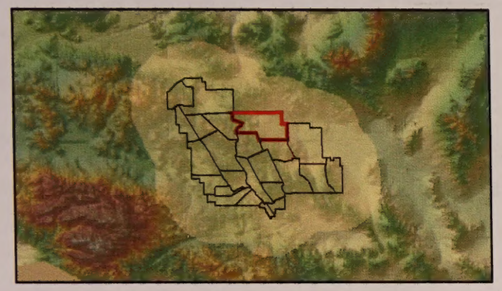


APPENDIX 2.
Land-use Model by RTA for each RTA

Marine Corps
Air Ground Combat Center
America Mine RTA

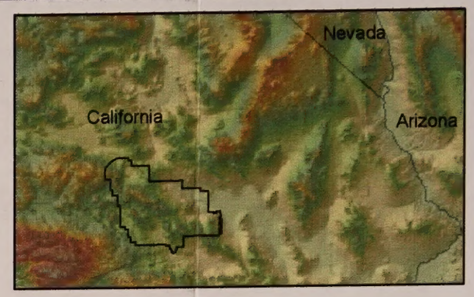
No plots were surveyed within America Mine RTA and no Uma were found.

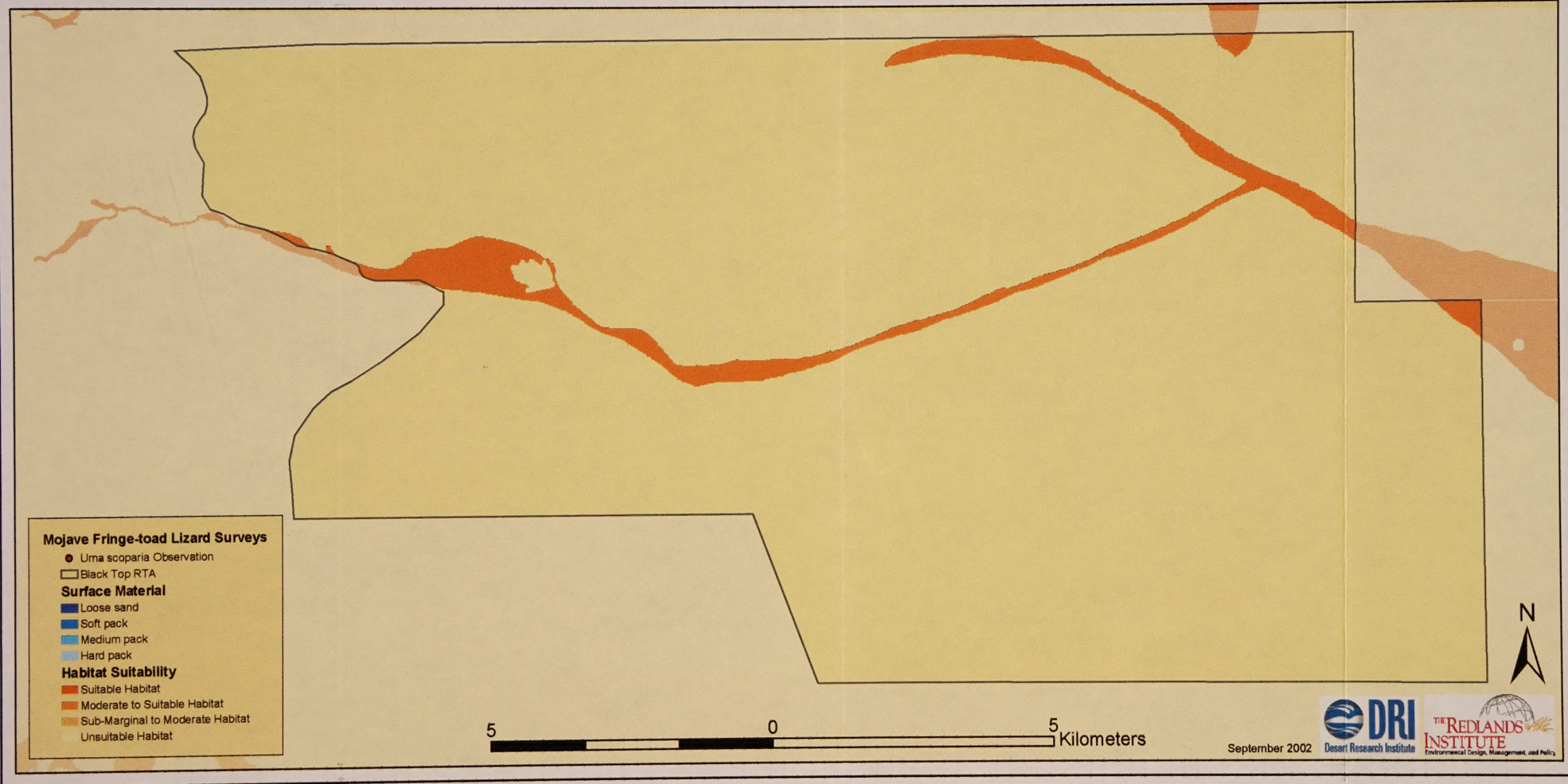




Marine Corps Air Ground Combat Center
Black Top RTA

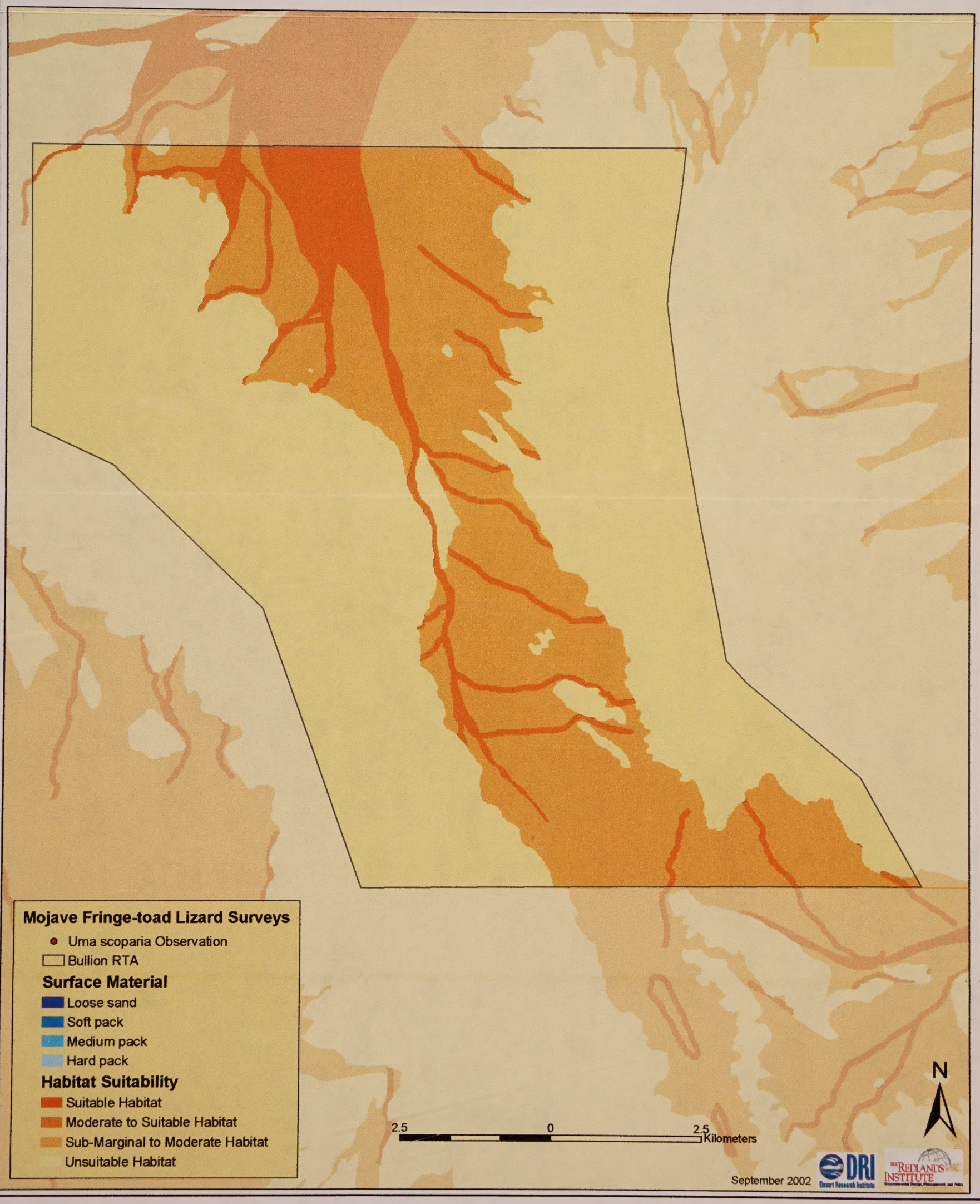
No plots were surveyed within Black Top RTA and no Uma were found.





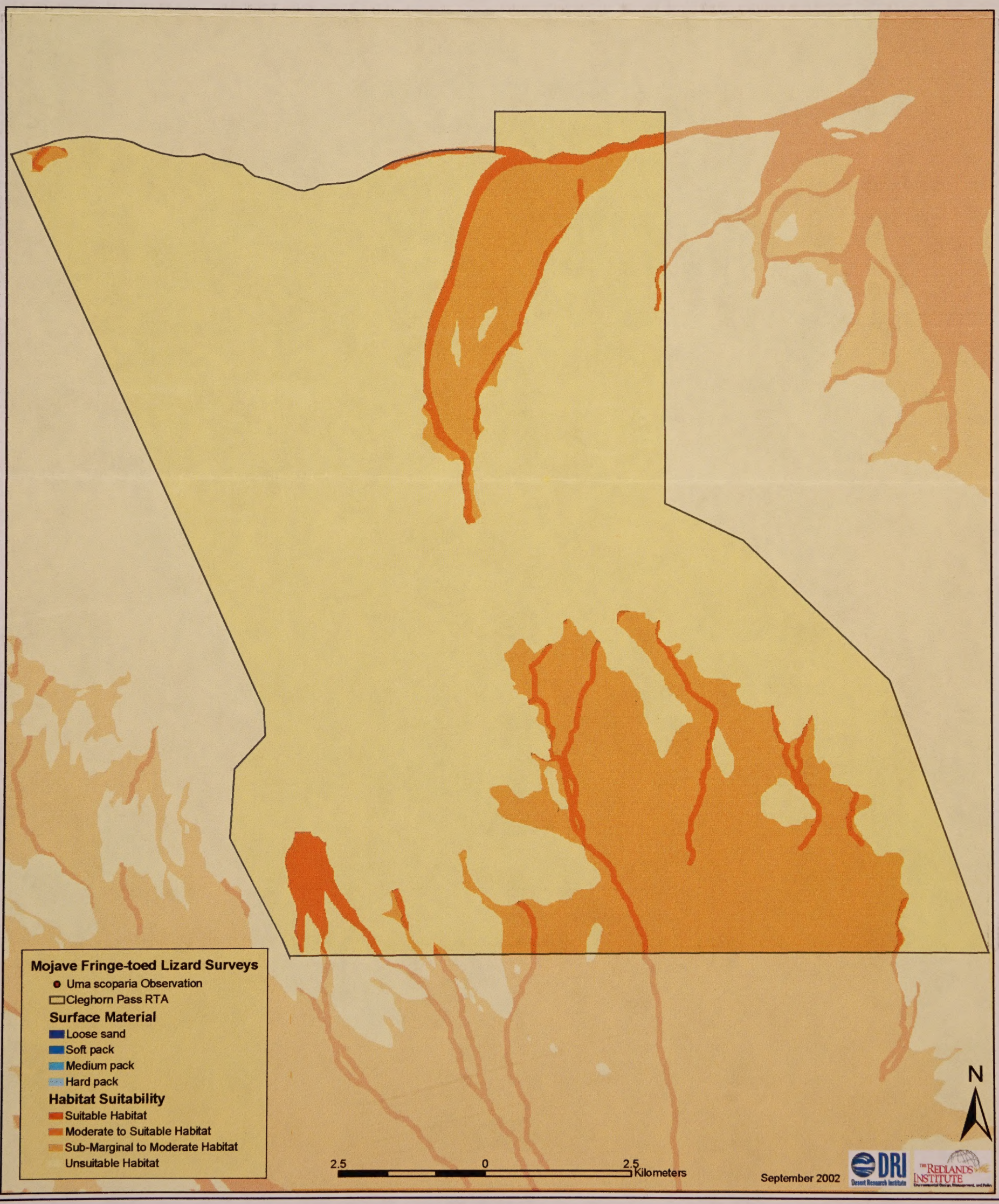
Marine Corps Air Ground Combat Center
Bullion RTA

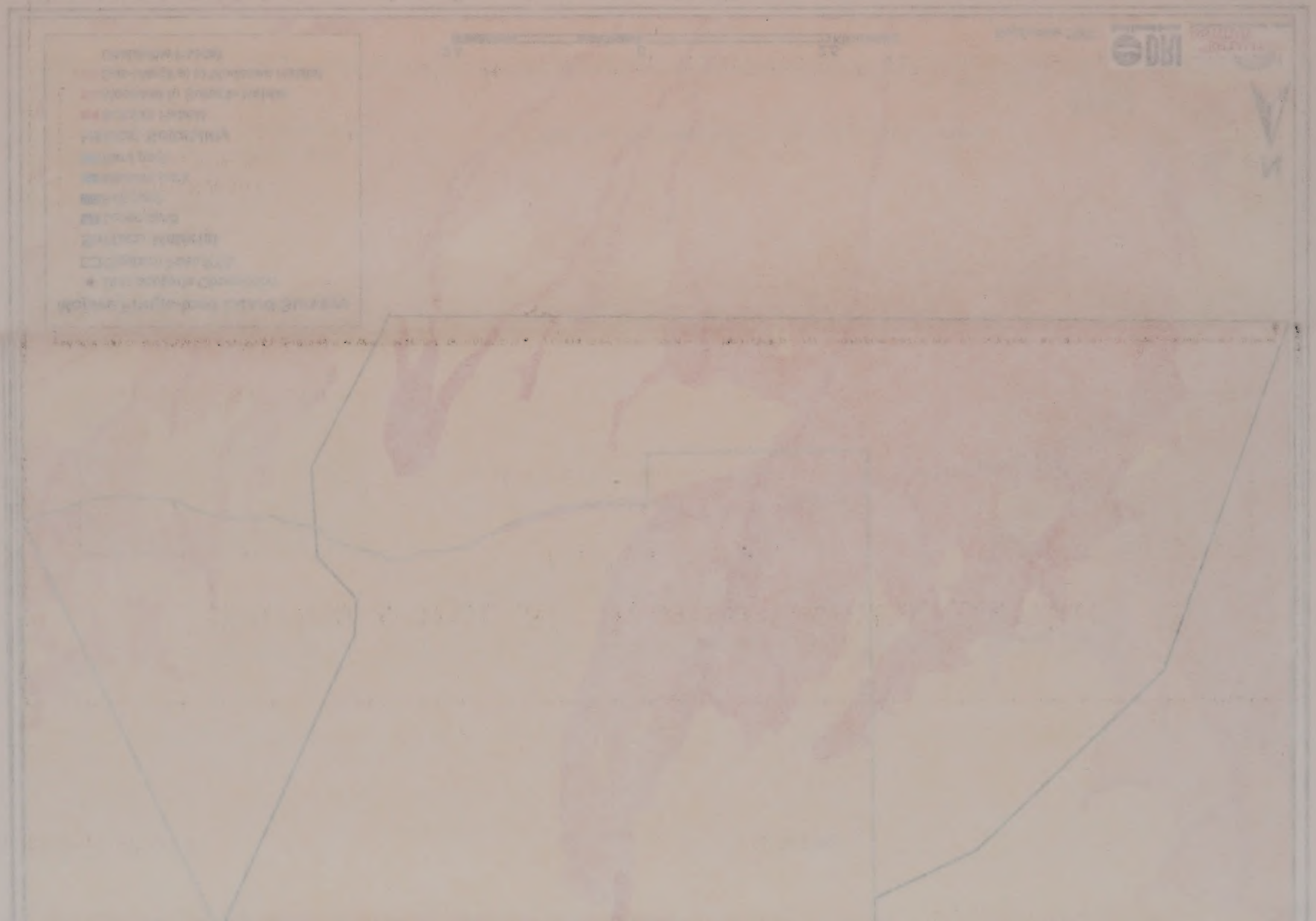
No plots were surveyed within Bullion RTA and no uma were found.



Marine Corps Air Ground Combat Center
Cleghorn Pass RTA

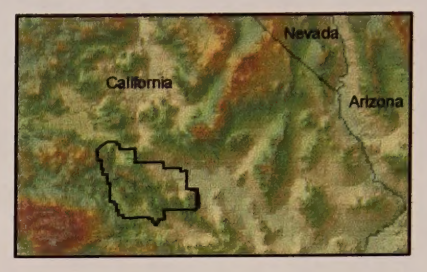
No plots were surveyed within Cleghorn Pass RTA and no Uma were found.

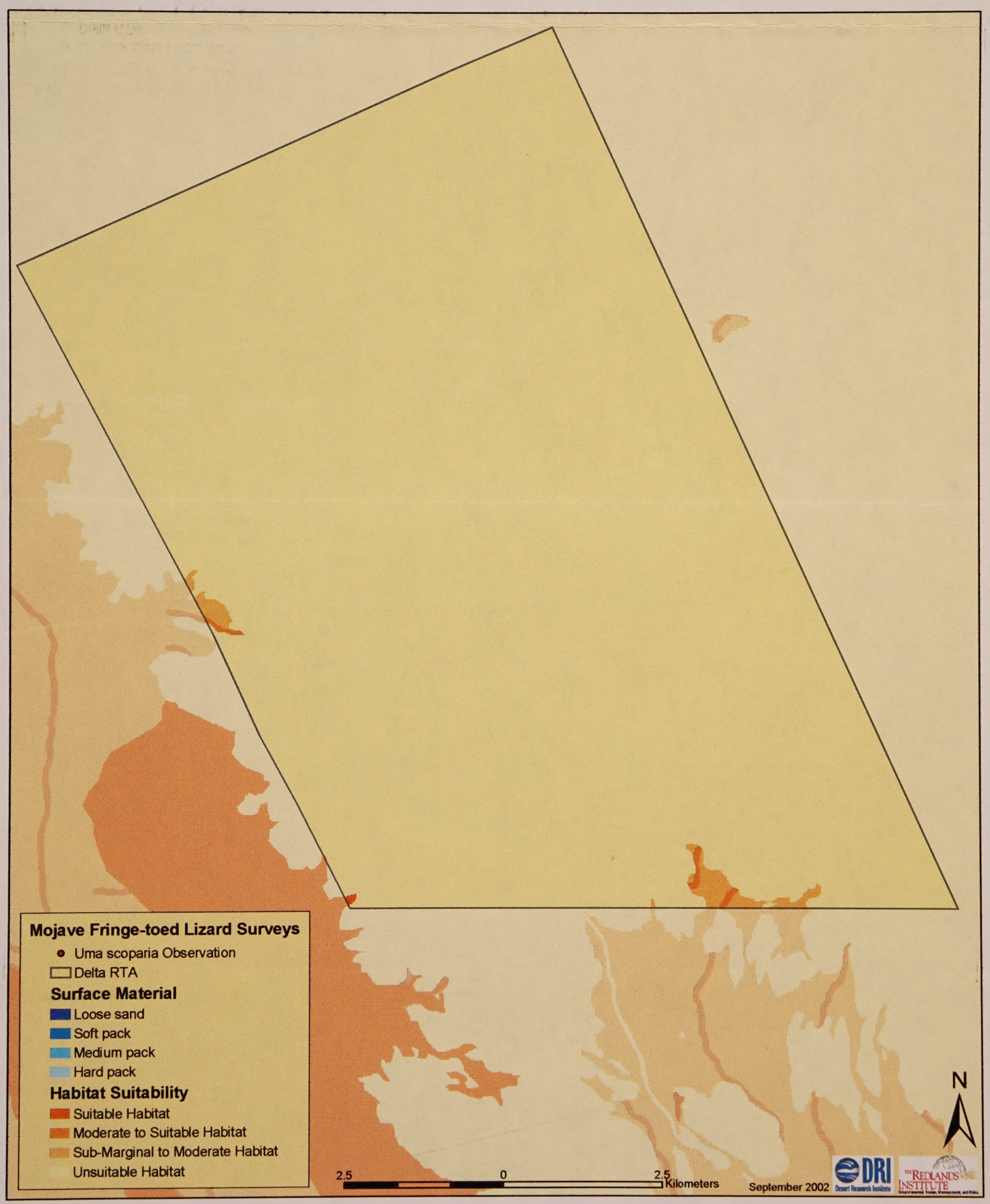




Marine Corps Air Ground Combat Center
Delta RTA

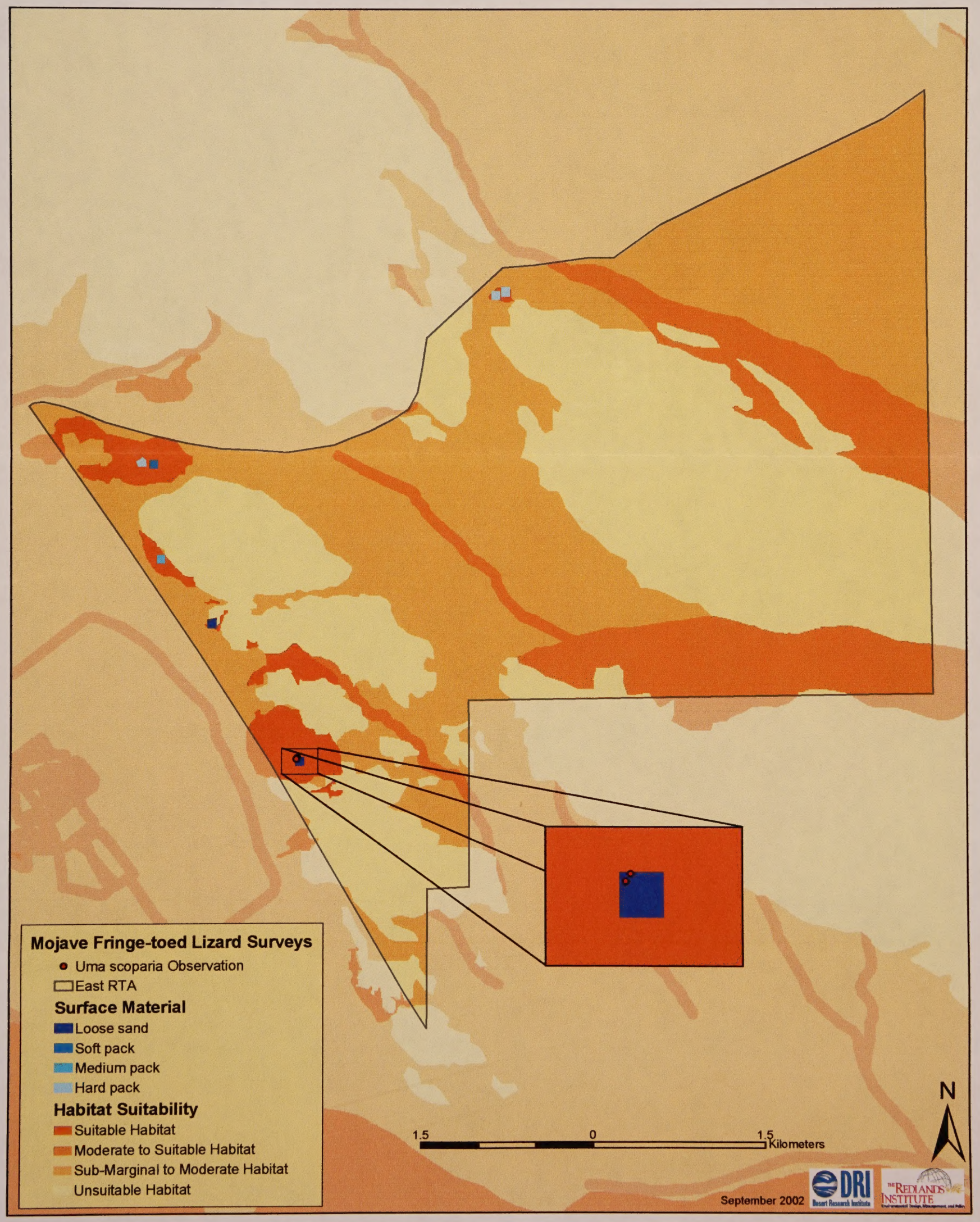
No plots were surveyed within Delta RTA and no Uma were found.





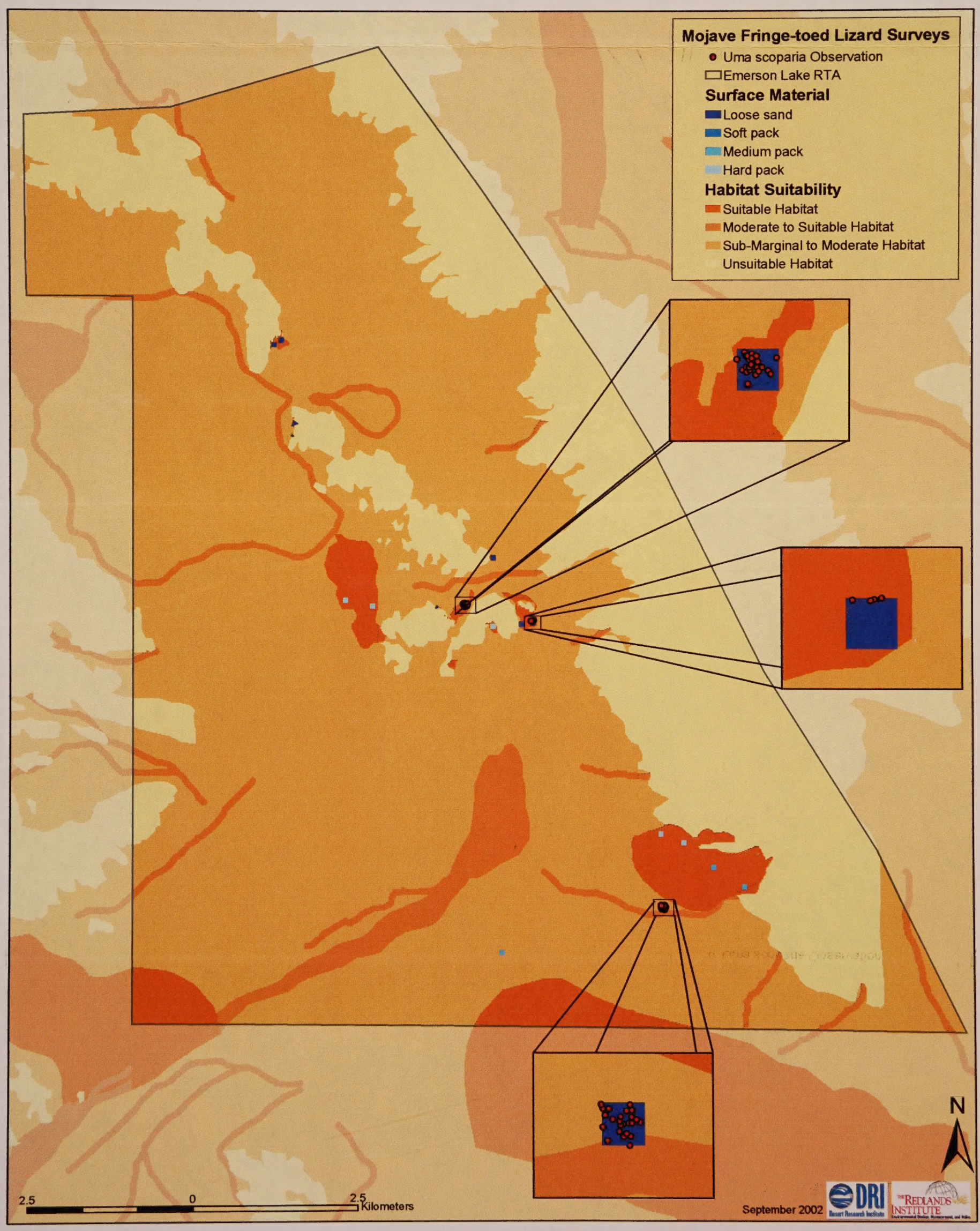
Marine Corps Air Ground Combat Center
East RTA

7 plots were surveyed within East RTA and
2 Uma were found.



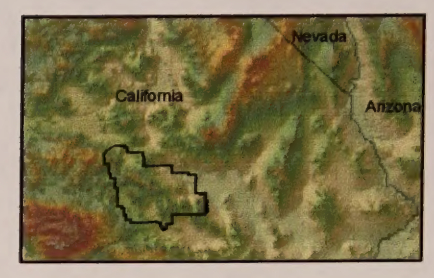
Marine Corps Air Ground Combat Center
Emerson Lake RTA

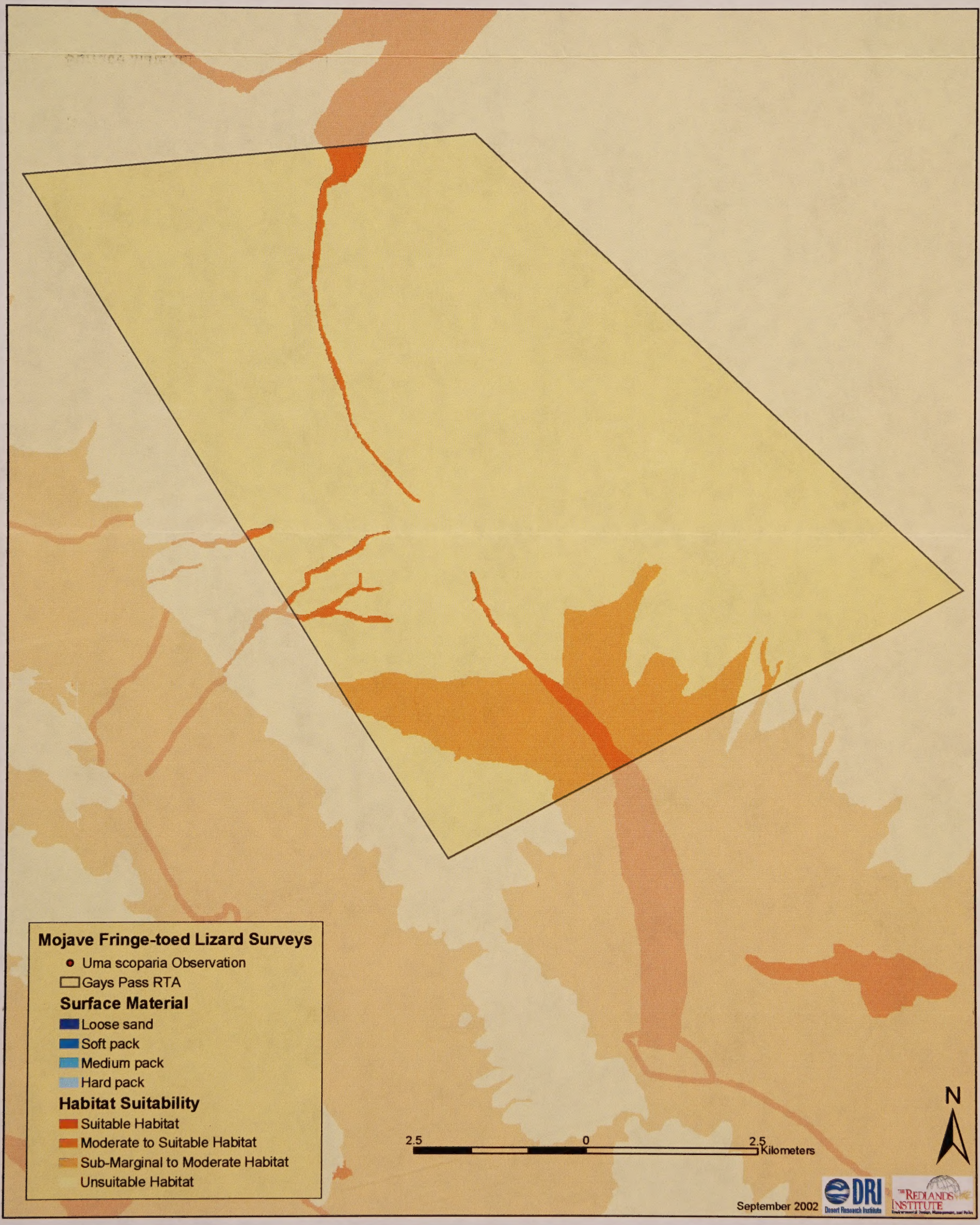
18 plots were surveyed within Emerson Lake RTA and
54 Uma were found.



Marine Corps Air Ground Combat Center
Gays Pass RTA

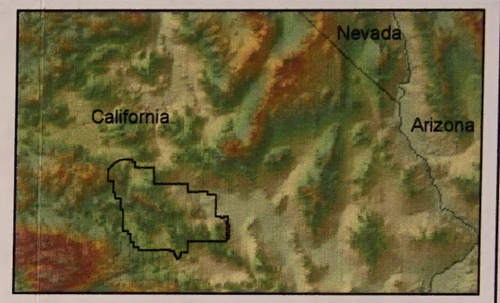
No plots were surveyed within Gays Pass RTA and no Uma were found.





Marine Corps Air Ground Combat Center
Gypsum Ridge RTA

6 plots were surveyed within Gypsum Ridge RTA and
11 Uma were found.



Marine Corps Air Ground Combat Center
Lava RTA

No plots were surveyed within Lava RTA and
no Uma were found.

Mojave Fringe-toed Lizard Surveys
- Uma scoparia Observation
- Lava RTA

Surface Material
- Loose sand
- Soft pack
- Medium pack
- Hard pack

Habitat Suitability
- Suitable Habitat
- Moderate to Suitable Habitat
- Sub-Marginal to Moderate Habitat
- Unsuitable Habitat

2.5 0 2.5 Kilometers

N

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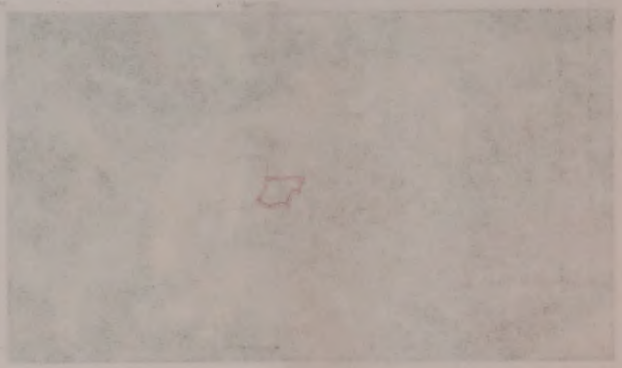
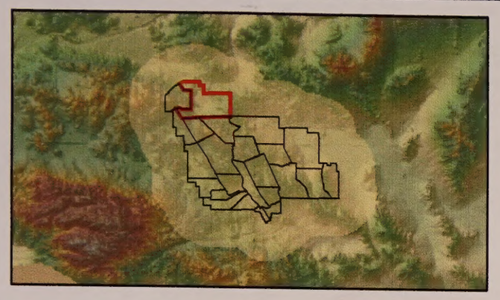
DRI Desert Research Institute

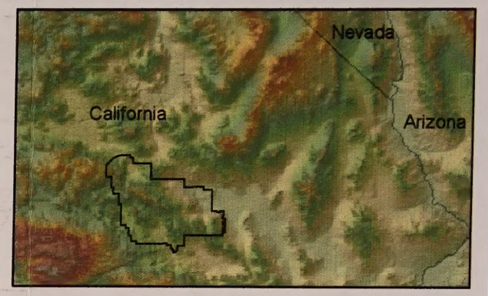
The Redlands Institute Environmental Design, Management, and Policy





Marine Corps Air Ground Combat Center
Lavic Lake RTA

8 plots were surveyed within Lavic Lake RTA and
12 Uma were found.



Mojave Fringe-toed Lizard Surveys
- Uma scoparia Observation
- Lavic Lake RTA

Surface Material
- Loose sand
- Soft pack
- Medium pack
- Hard pack

Habitat Suitability
- Suitable Habitat
- Moderate to Suitable Habitat
- Sub-Marginal to Moderate Habitat
- Unsuitable Habitat

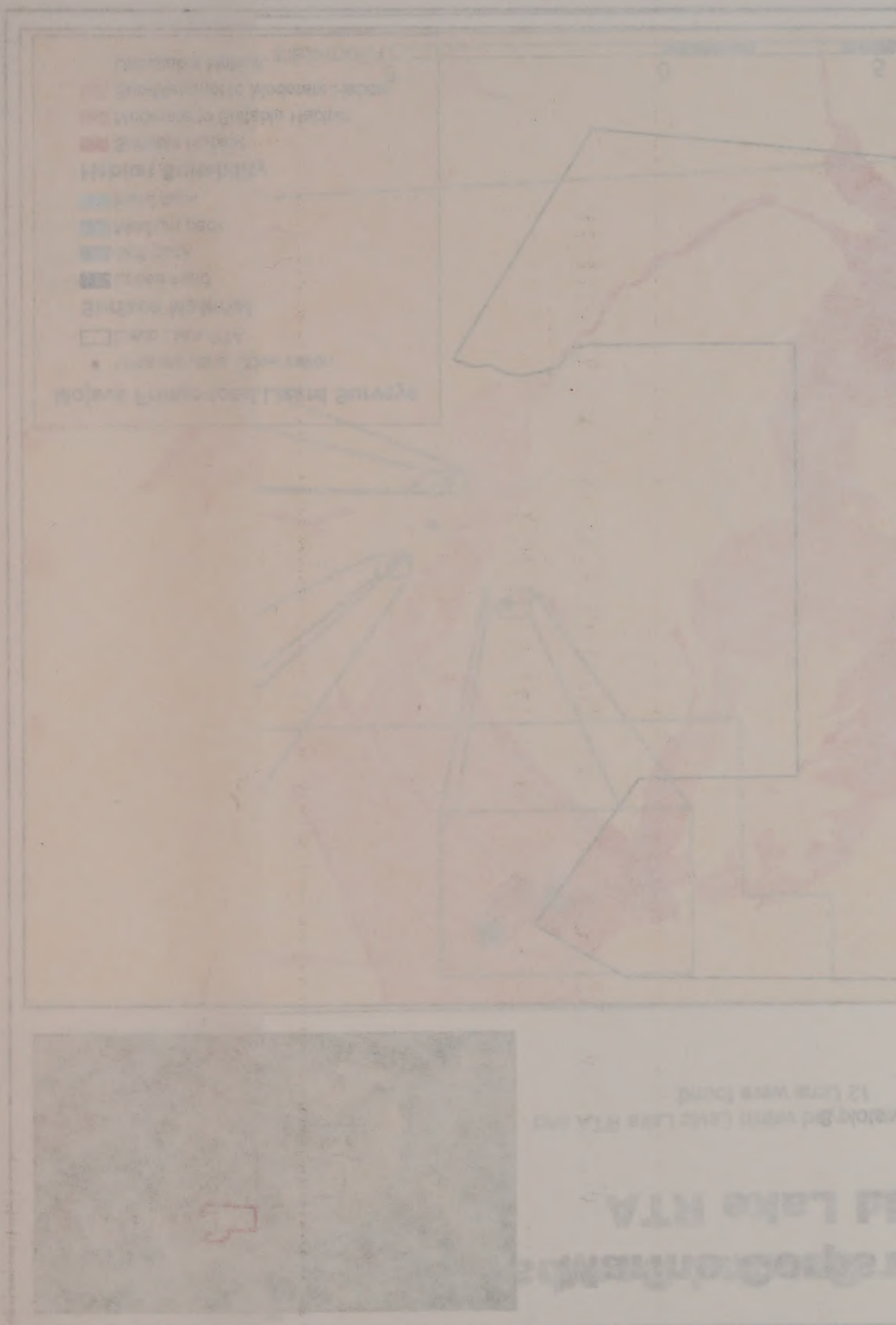
5 0 5 Kilometers

N

September 2002

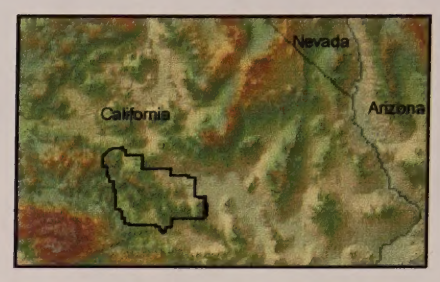
DRI Desert Research Institute

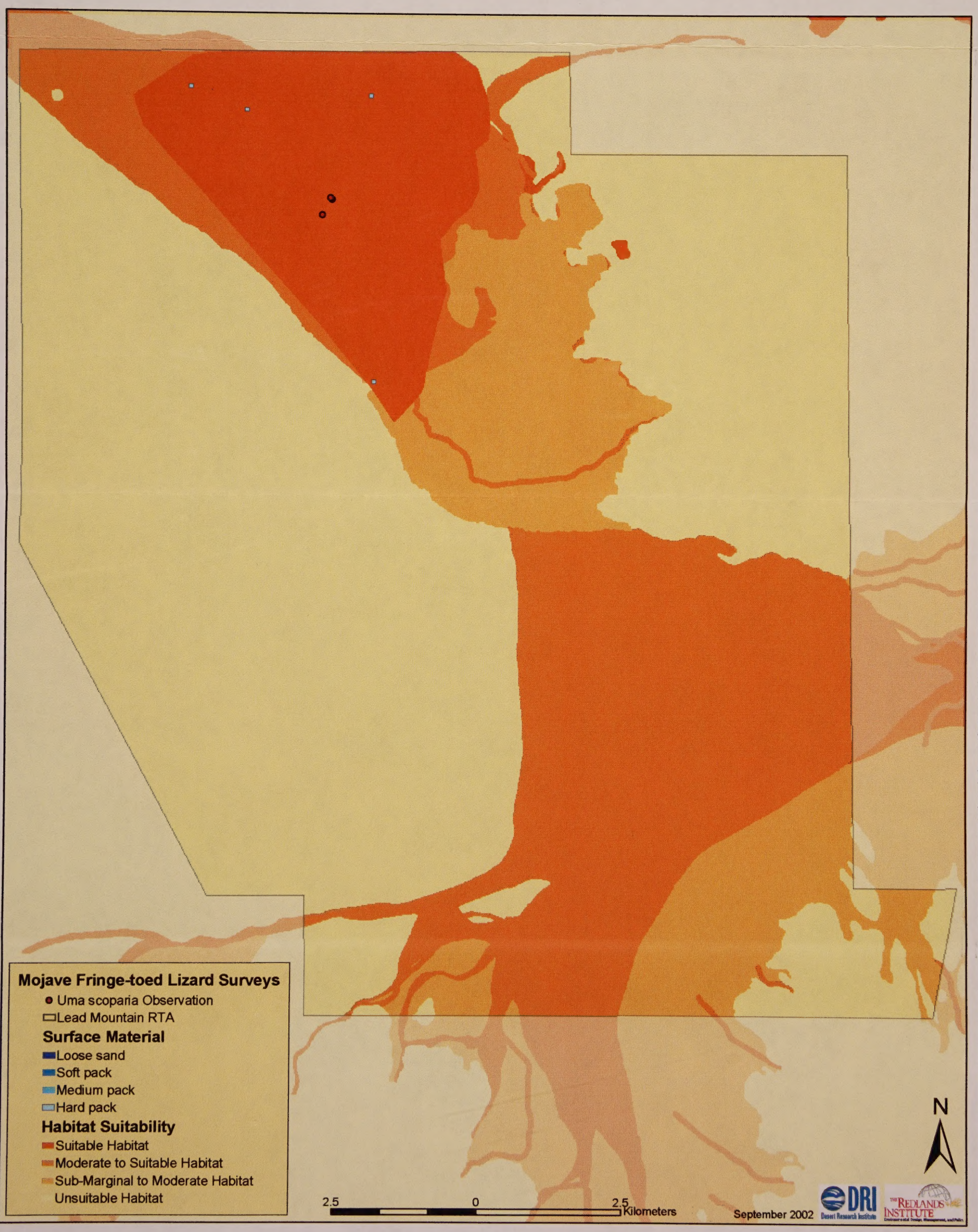
The Redlands Institute
Environmental Design, Management, and Policy



Marine Corps Air Ground Combat Center
Lead Mountain RTA

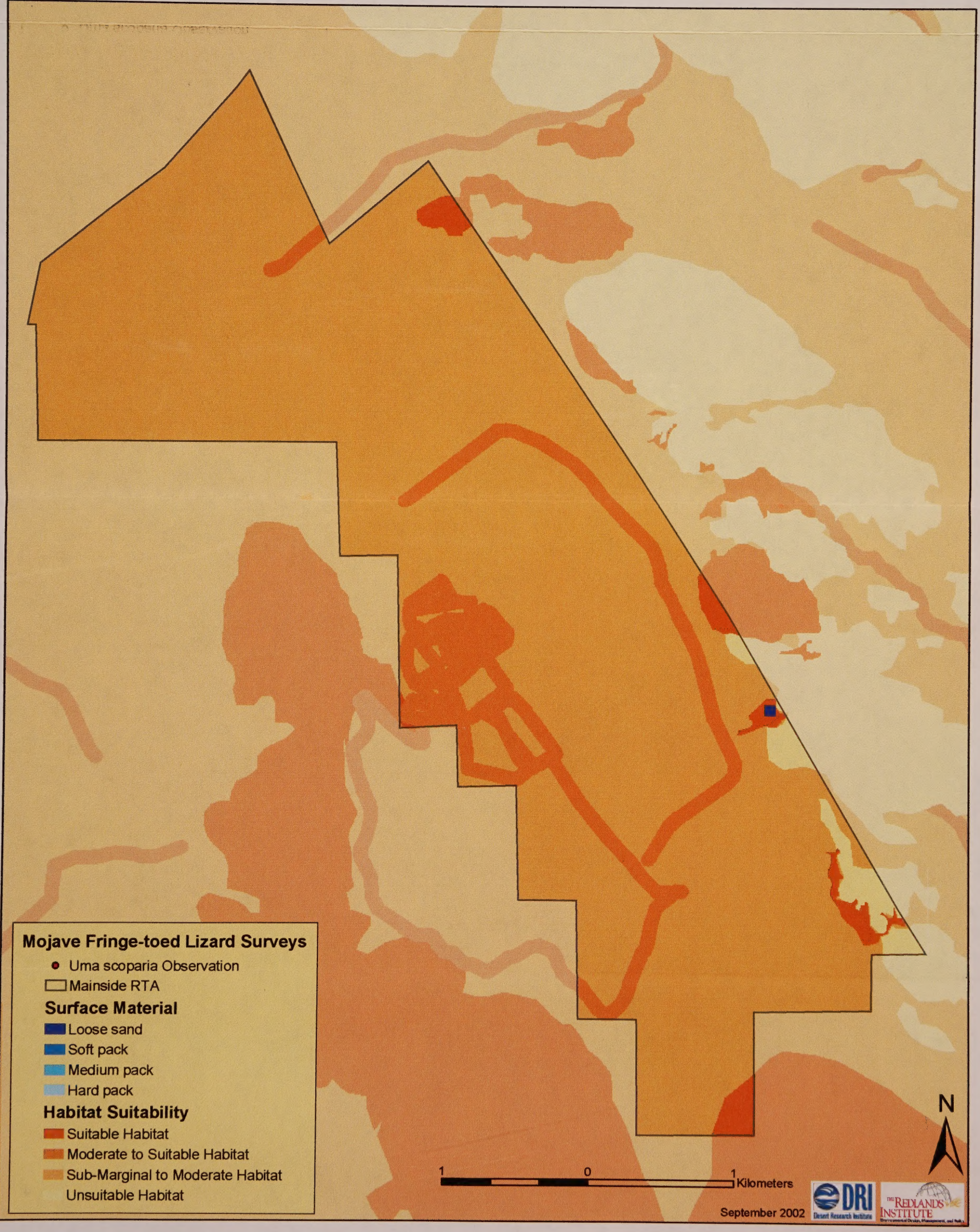
6 plots were surveyed within Lead Mountain RTA and
3 Uma were found.

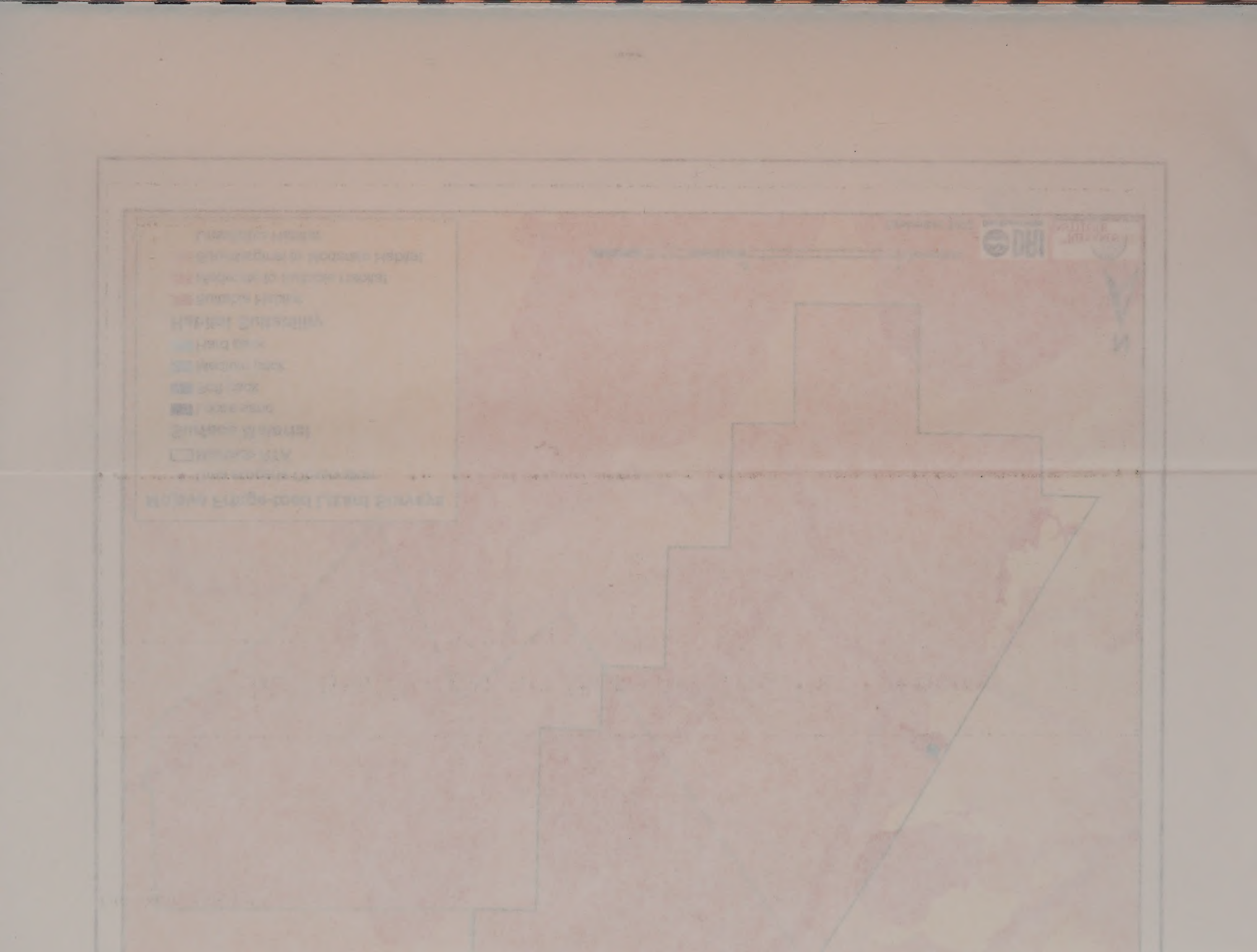




Marine Corps Air Ground Combat Center
Mainside RTA

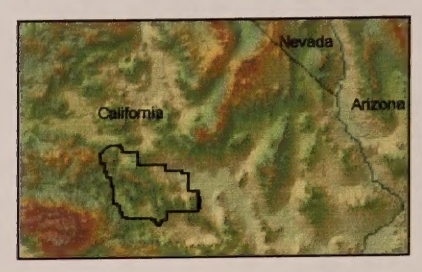
1 plot was surveyed within Mainside RTA and no Uma were found.

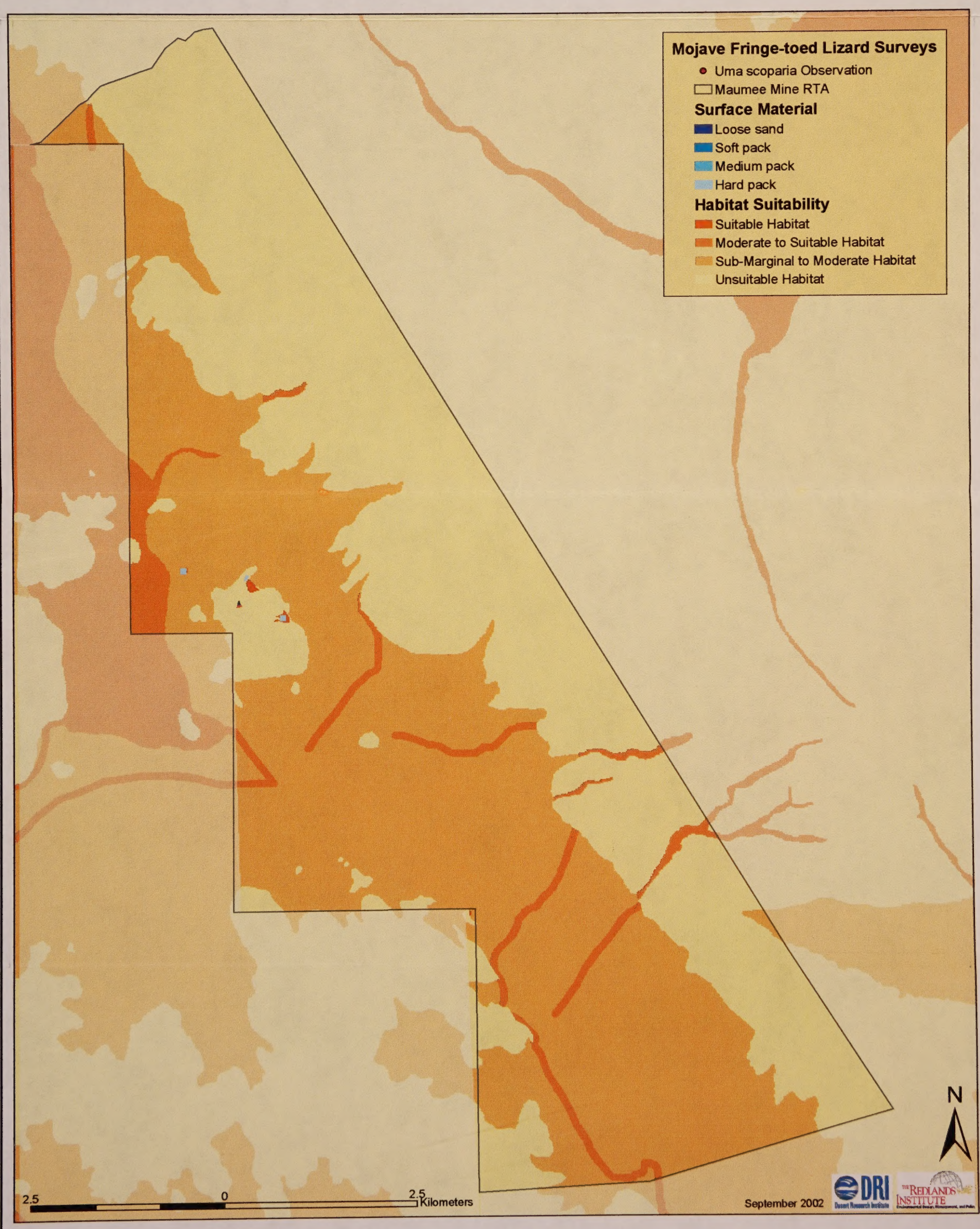


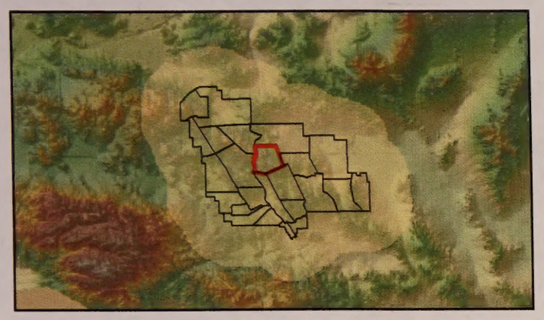


Marine Corps Air Ground Combat Center
Maumee Mine RTA

4 plots were surveyed within Maumee Mine RTA and no Uma were found.

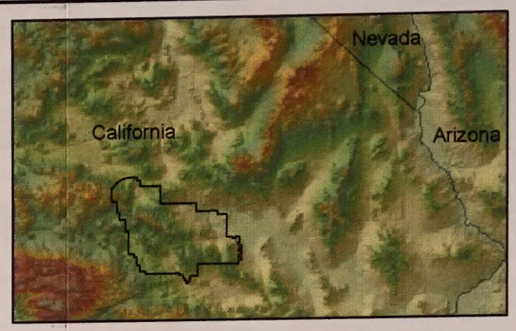






Marine Corps Air Ground Combat Center
Noble Pass RTA

No plots were surveyed within Noble Pass and
no Uma were found.



Mojave Fringe-toed Lizard Surveys
- Uma scoparia Observation
- Noble Pass RTA

Surface Material
- Loose sand
- Soft pack
- Medium pack
- Hard pack

Habitat Suitability
- Suitable Habitat
- Moderate to Suitable Habitat
- Sub-Marginal to Moderate Habitat
- Unsuitable Habitat

5 0 5 Kilometers

N

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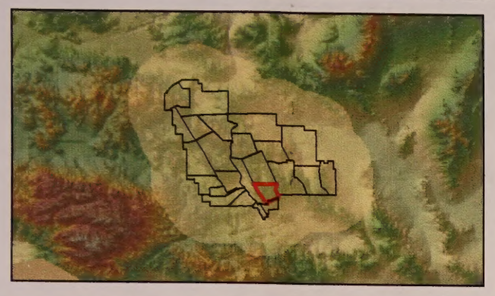
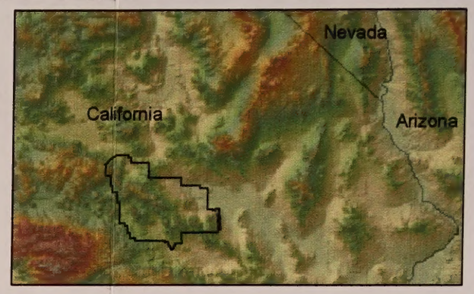
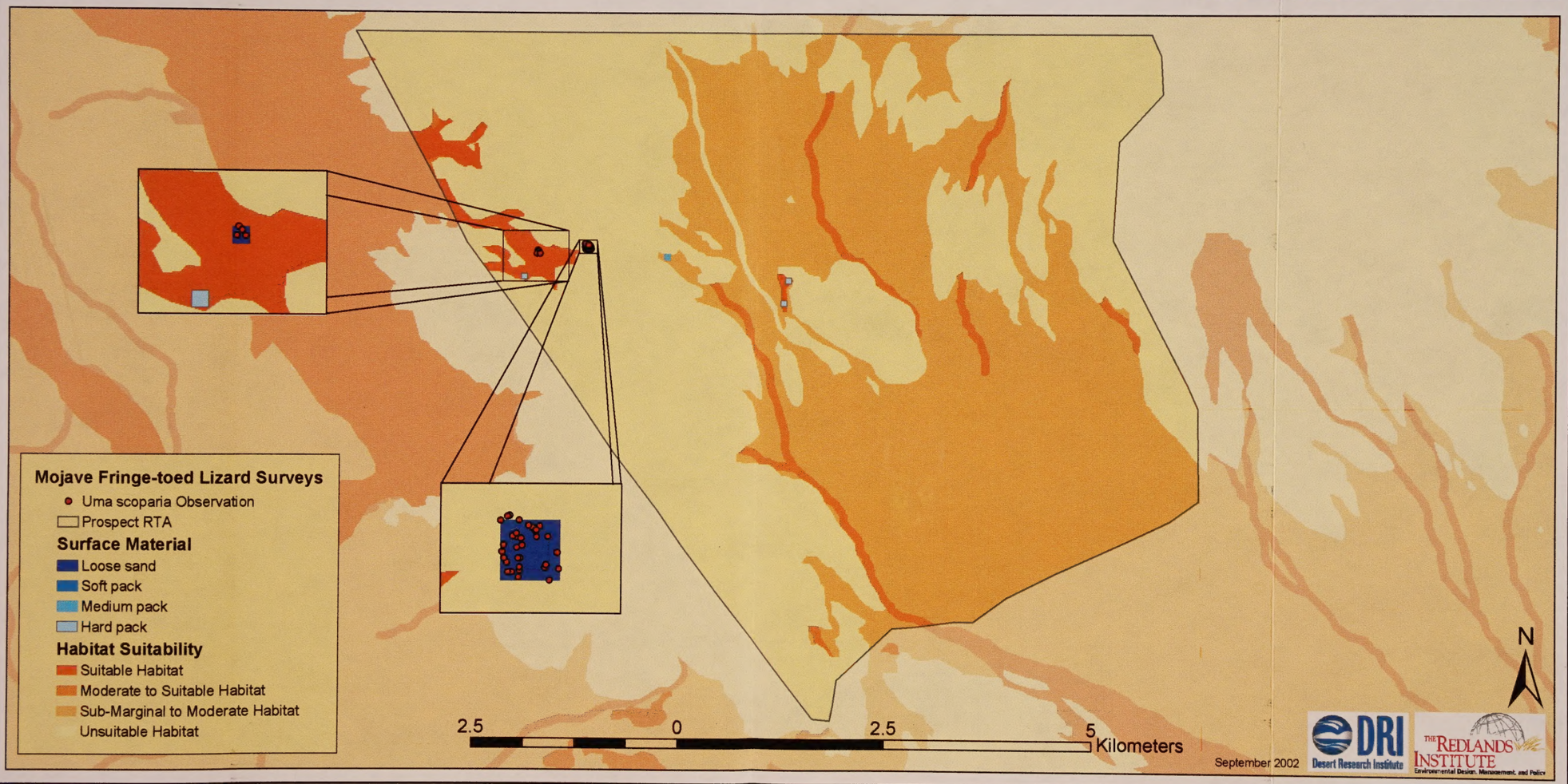
Environmental Design, Management, and Policy



Marine Corps Air Ground Combat Center
Prospect RTA

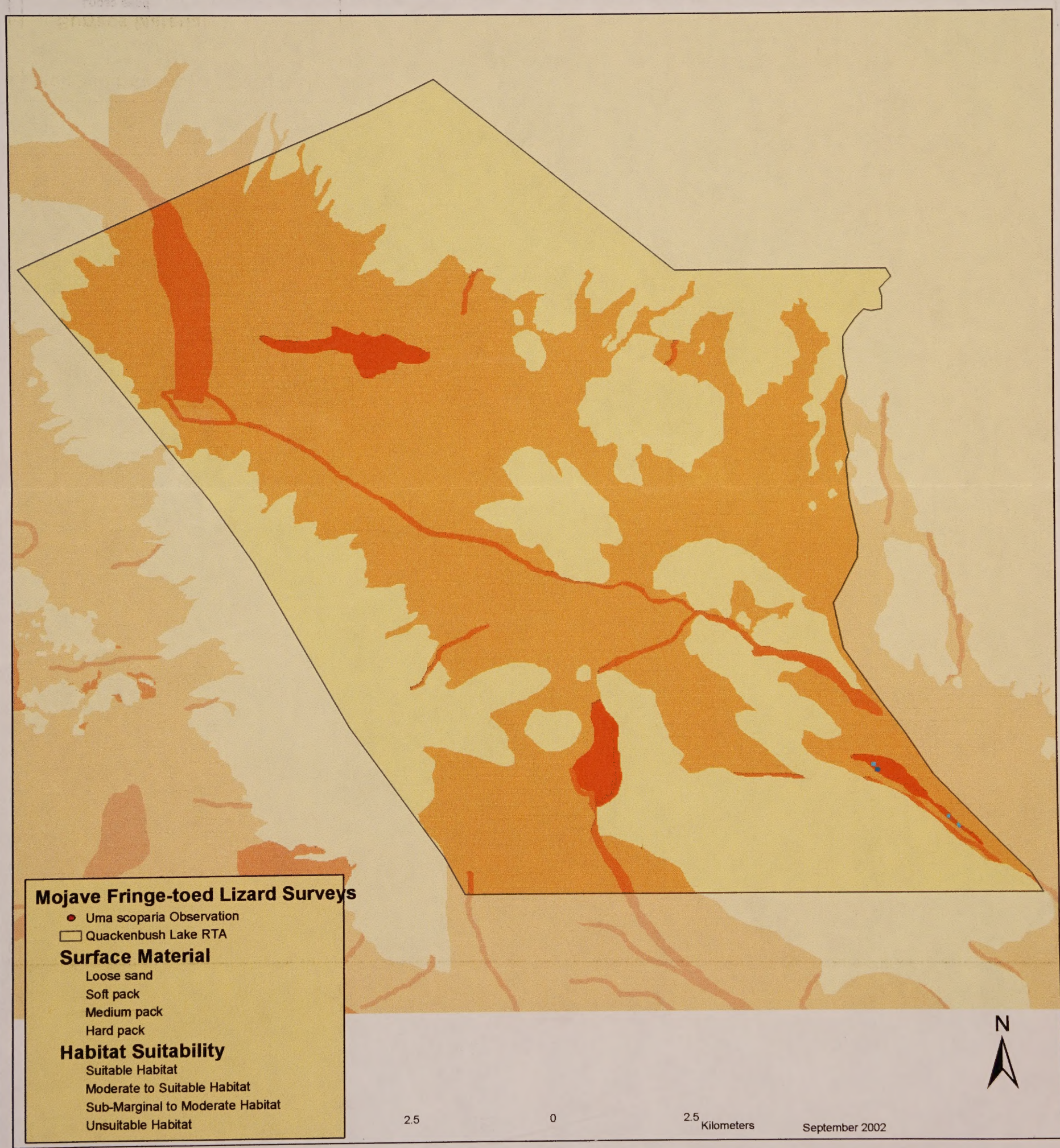
6 plots were surveyed within Prospect RTA and
37 Uma were found.

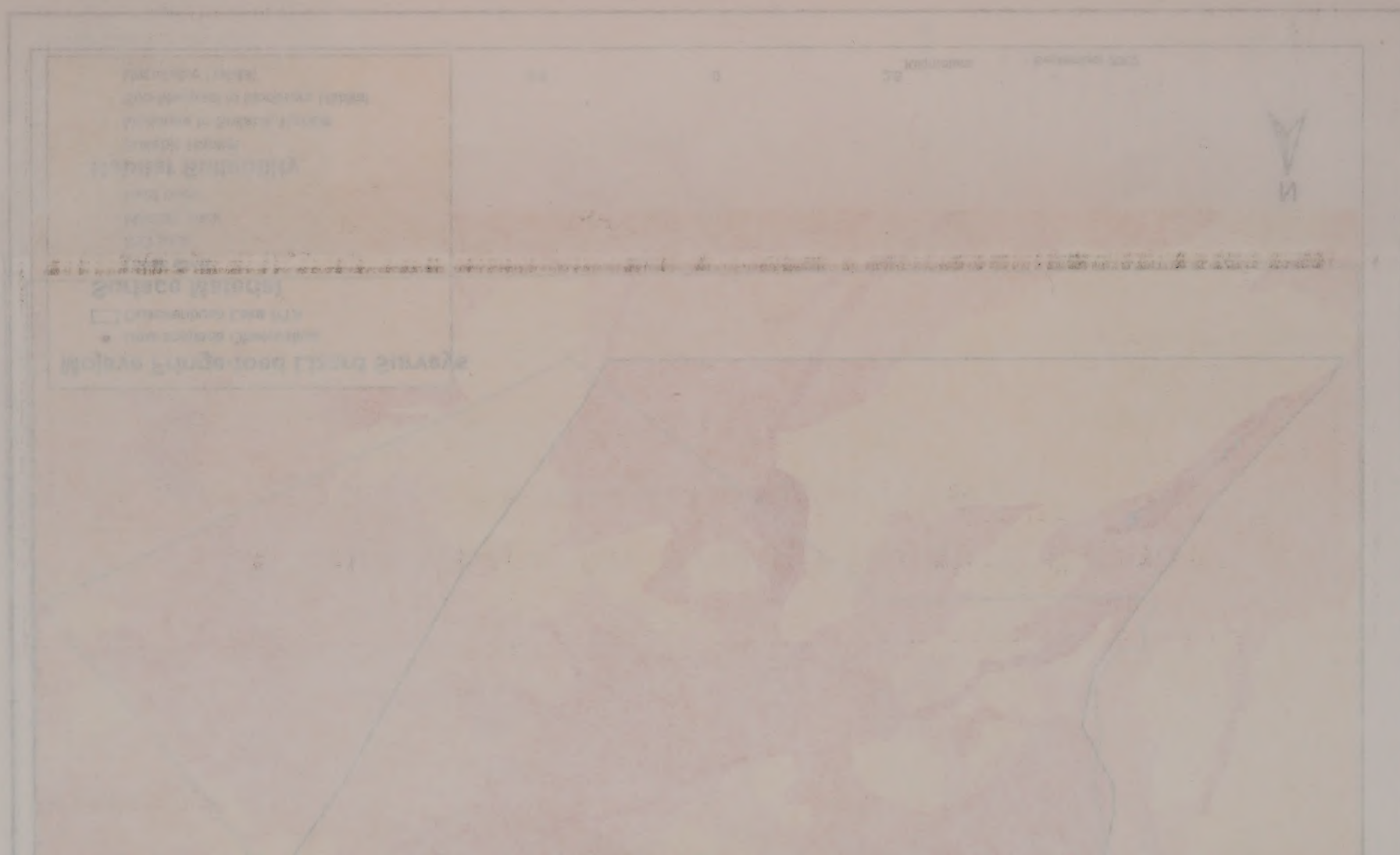




Marine Corps Air Ground Combat Center
Quackenbush Lake RTA

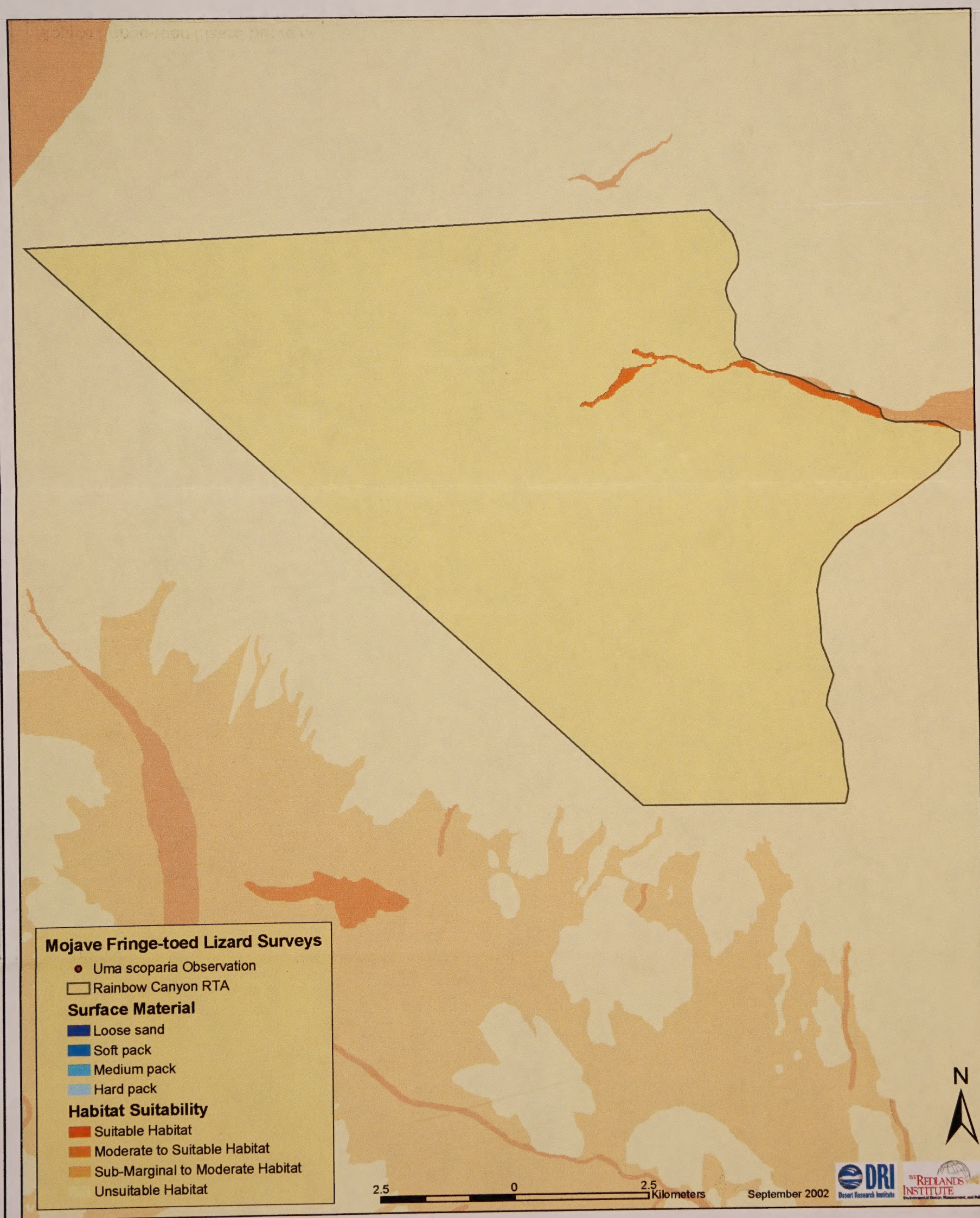
4 plots were surveyed within Quackenbush Lake RTA and no Uma were found.





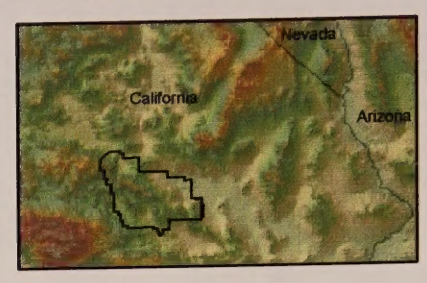
Marine Corps Air Ground Combat Center
Rainbow Canyon RTA

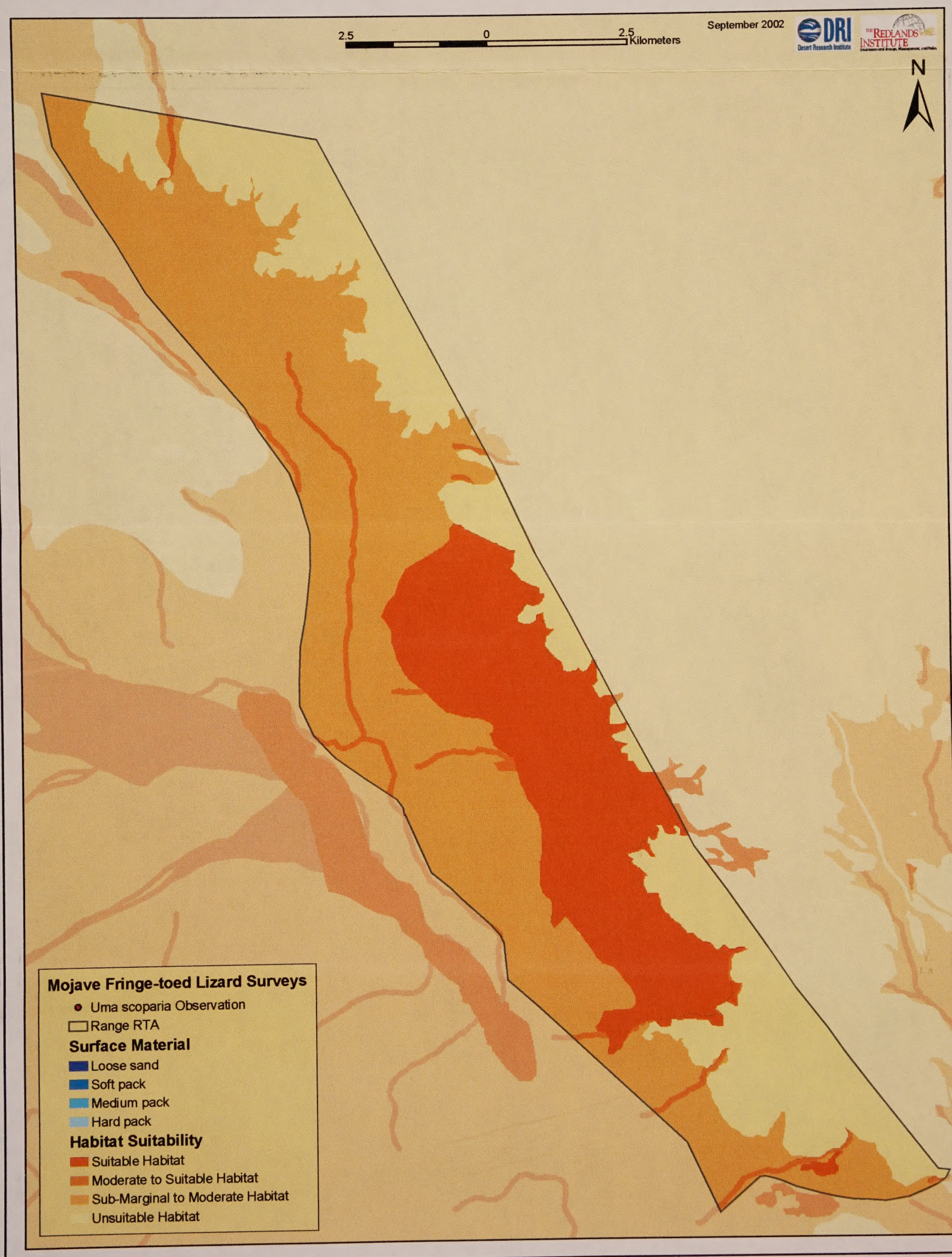
No plots were surveyed within Rainbow Canyon and no Uma were found.

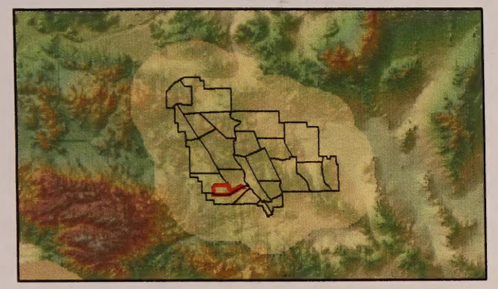


Marine Corps Air Ground Combat Center
Range RTA

No plots were surveyed within Range RTA and
no Uma were found.

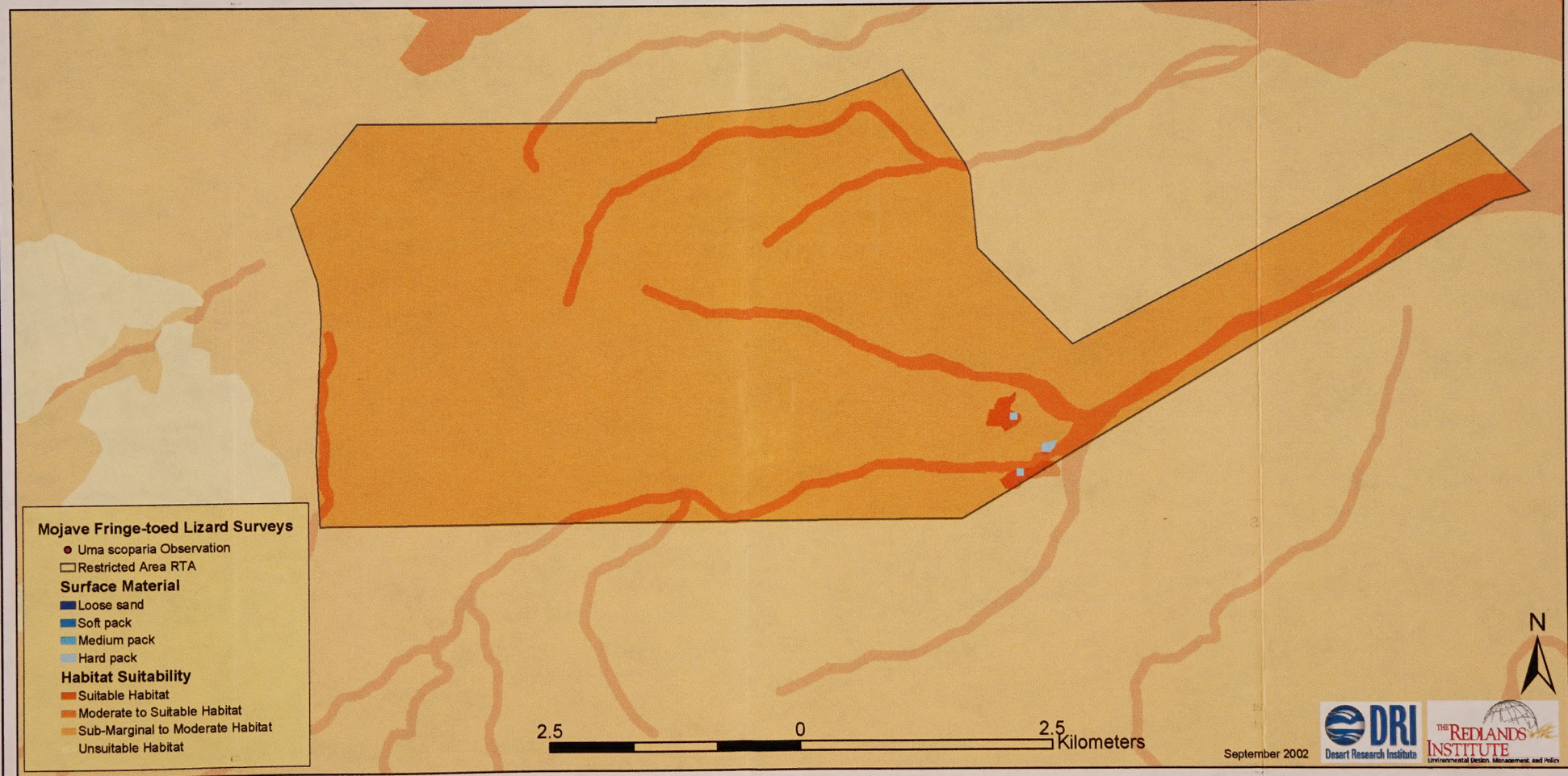


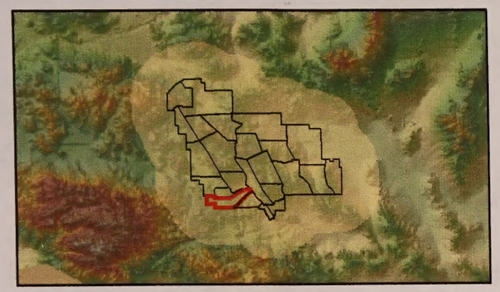




Marine Corps Air Ground Combat Center
Restricted Area RTA

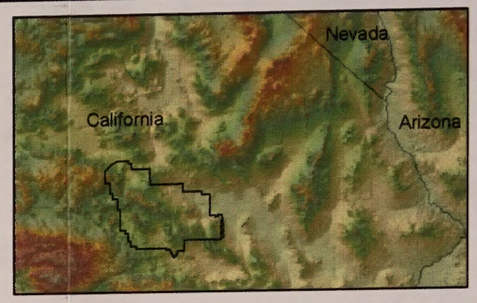
3 plots were surveyed within Restricted Area RTA and
no Uma were found.



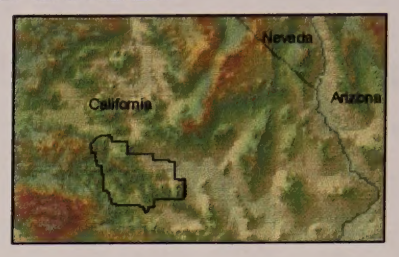


Marine Corps Air Ground Combat Center
Sandhill RTA

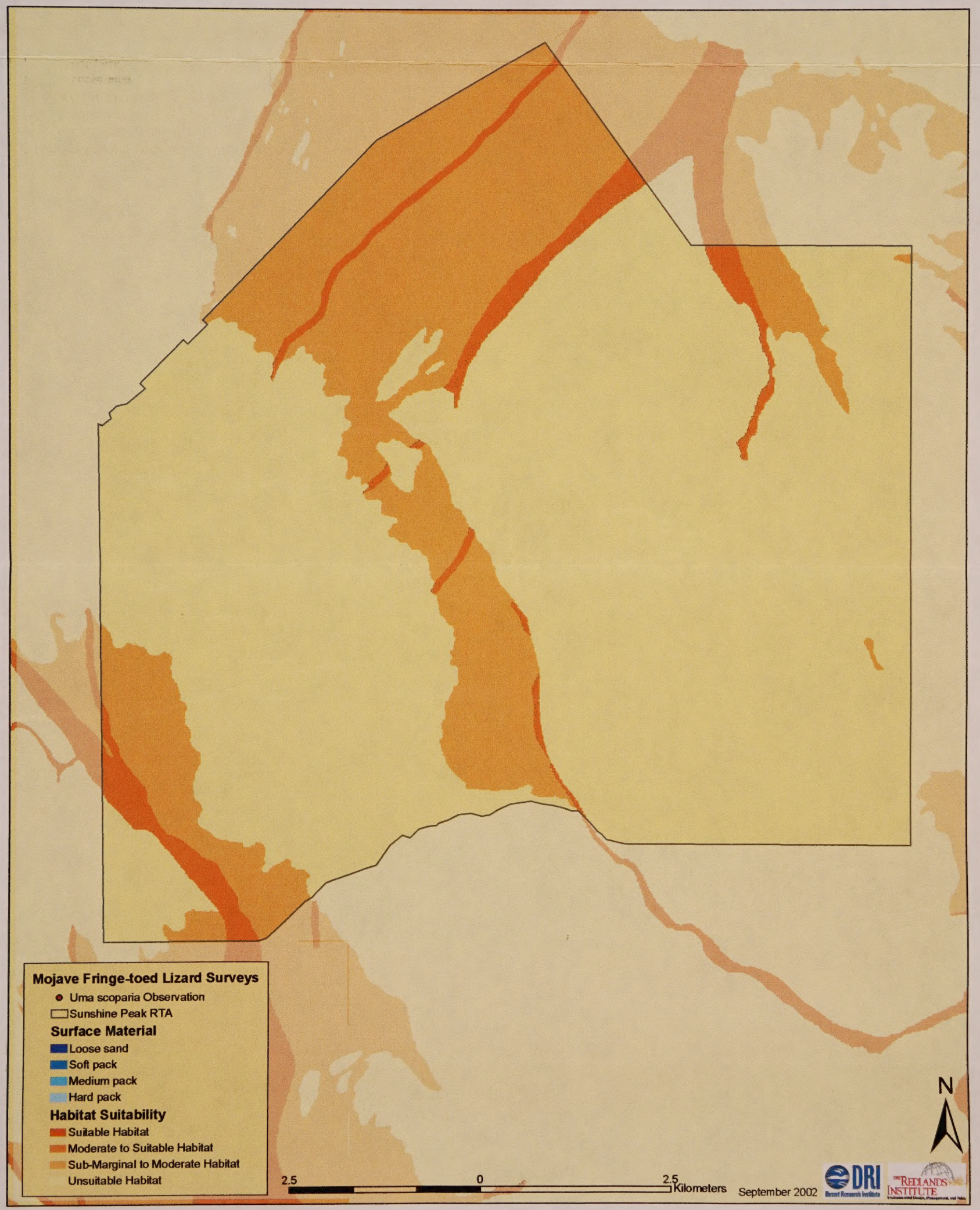
1 plot was surveyed within Sandhill RTA and
no Uma were found.

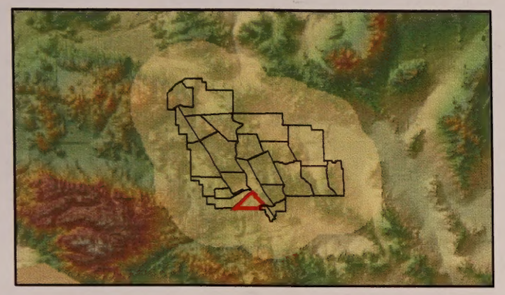


Marine Corps Air Ground Combat Center
Sunshine Peak RTA



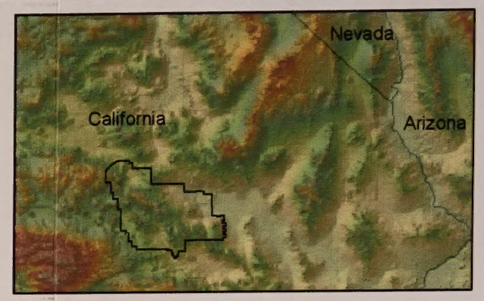
No plots were surveyed within Sunshine Peak RTA and no Uma were found.



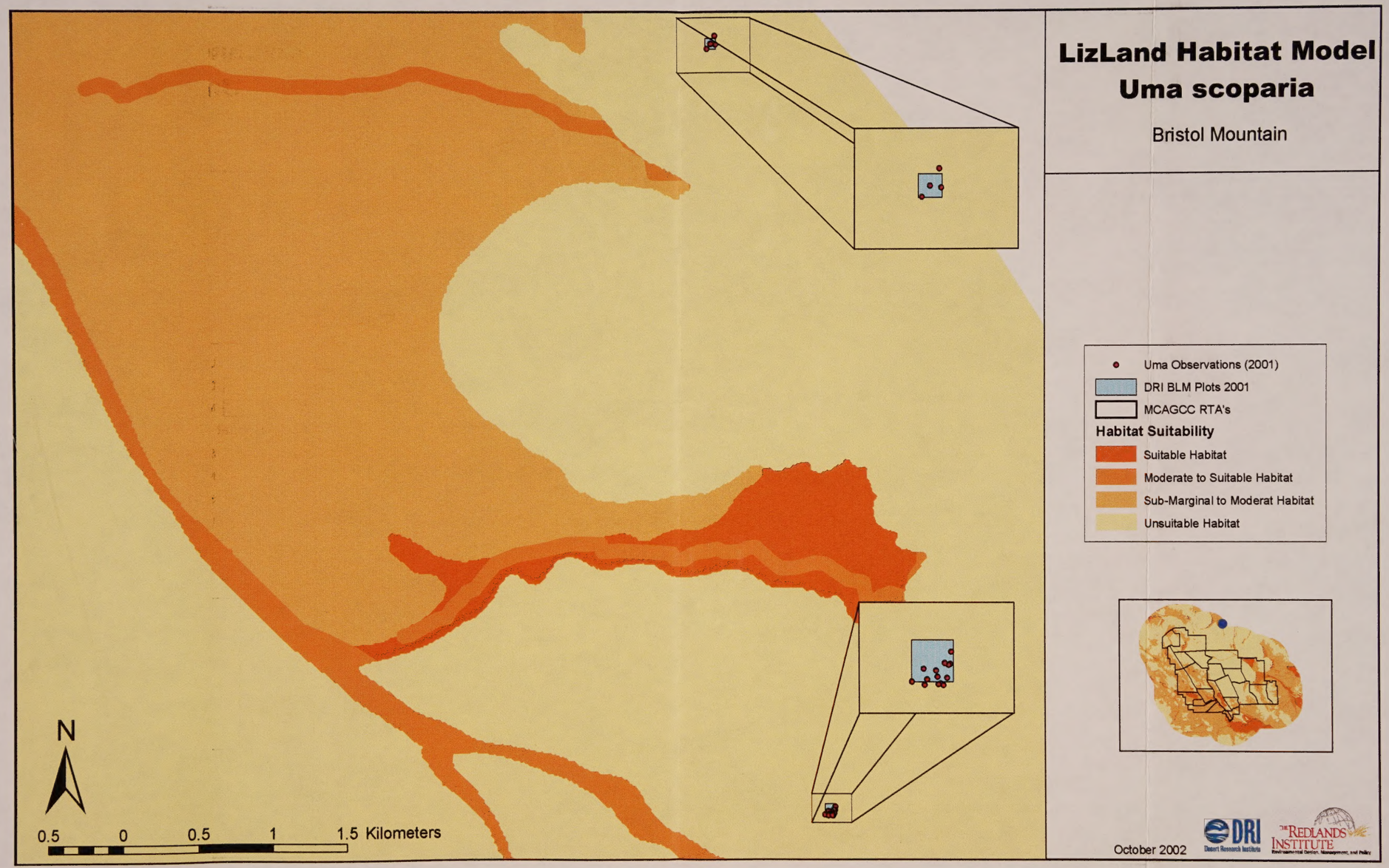


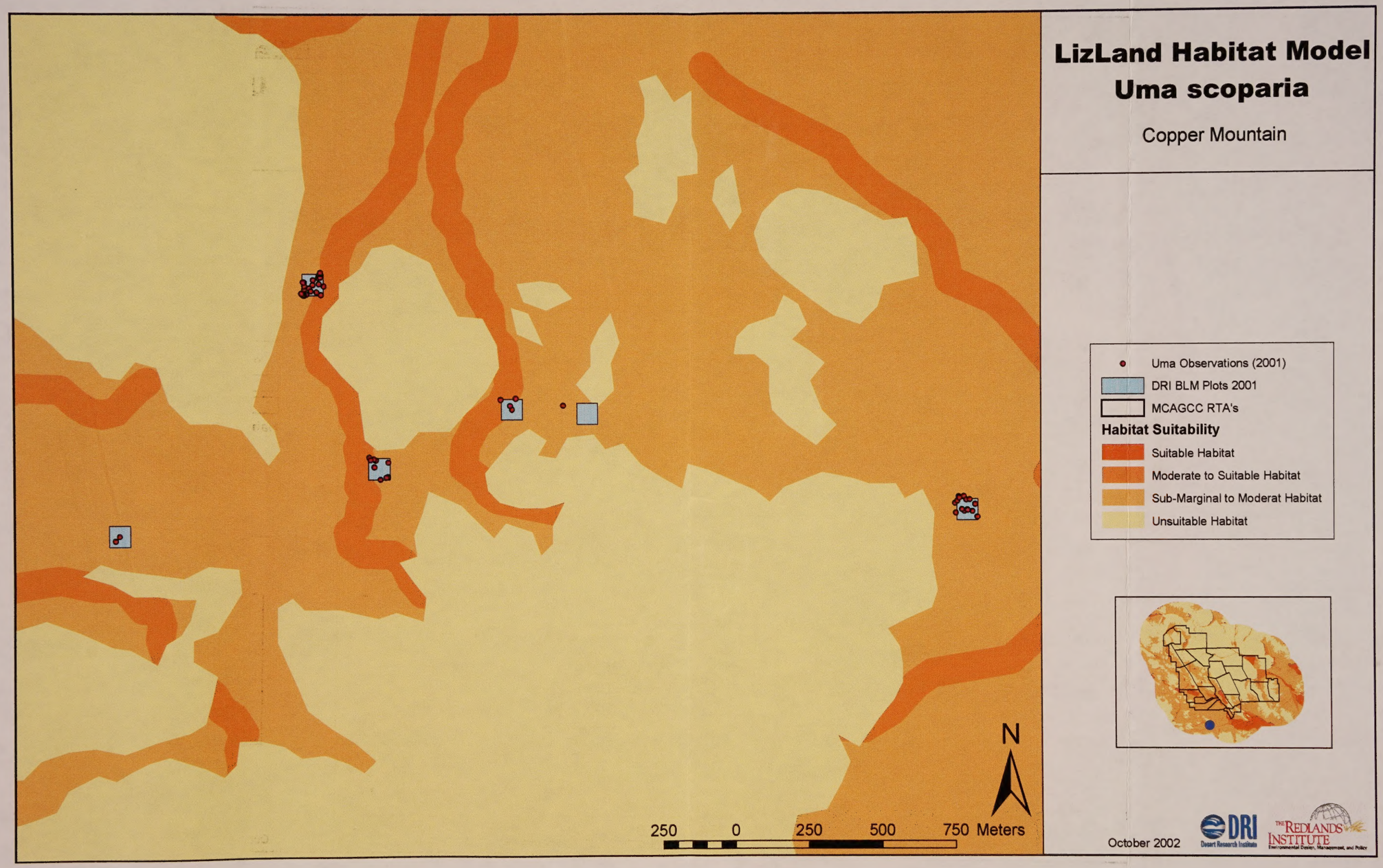
Marine Corps Air Ground Combat Center
West RTA

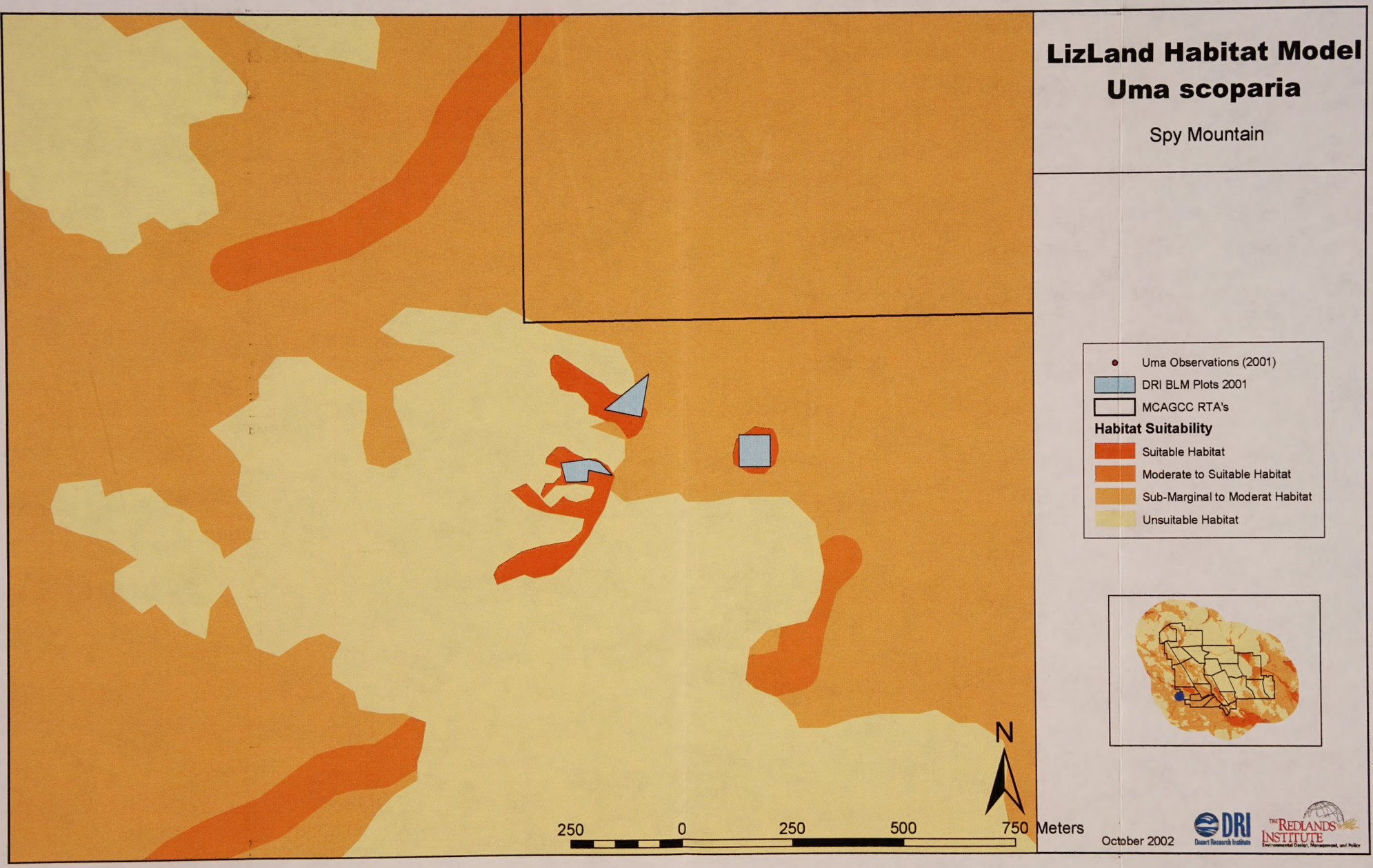
3 plots were surveyed within West RTA and
no Uma were found.

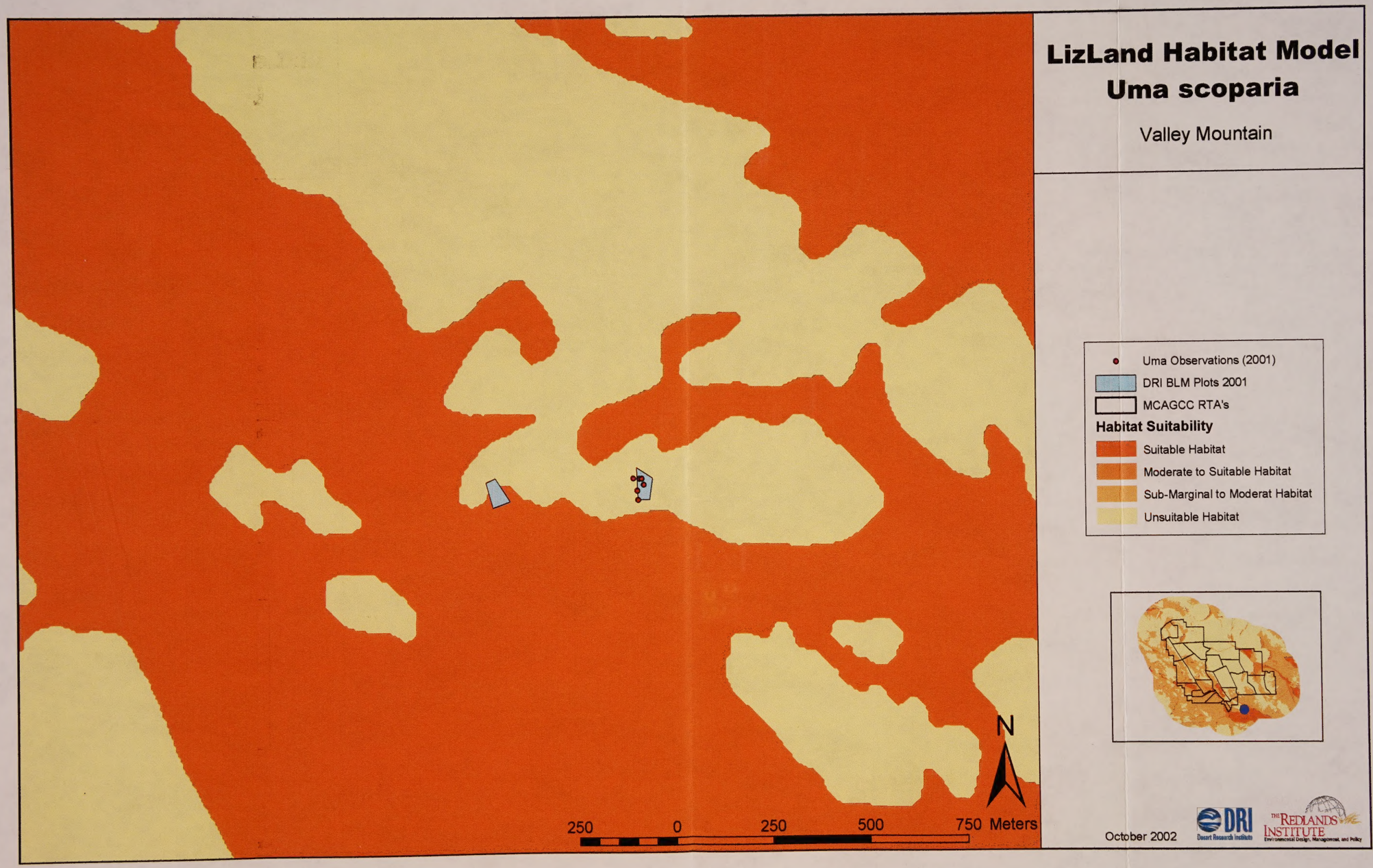


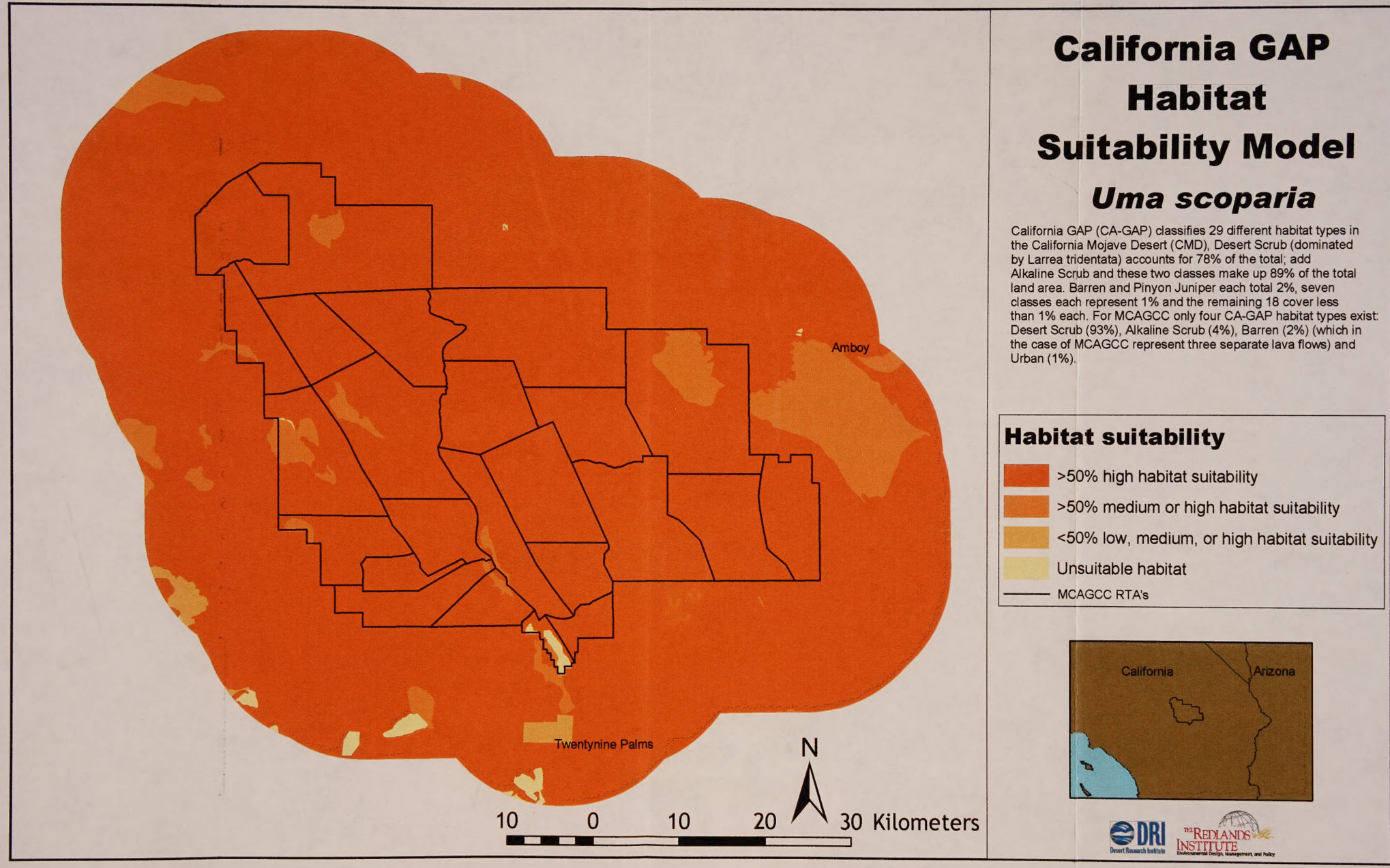
APPENDIX 3.
LizLand models for BLM surveyed areas.




LizLand Habitat Model
Uma scoparia
Copper Mountain
Uma Observations (2001)
DRI BLM Plots 2001
MCAGCC RTA's
Habitat Suitability
Suitable Habitat
Moderate to Suitable Habitat
Sub-Marginal to Moderat Habitat
Unsuitable Habitat
N
250 0 250 500 750 Meters
October 2002
DRI
Desert Research Institute
The Redlands Institute


LizLand Habitat Model
Uma scoparia
Spy Mountain
Uma Observations (2001)
DRI BLM Plots 2001
MCAGCC RTA's
Habitat Suitability
Suitable Habitat
Moderate to Suitable Habitat
Sub-Marginal to Moderat Habitat
Unsuitable Habitat
N
250 0 250 500 750 Meters
October 2002
DRI
Desert Research Institute
THE REDLANDS INSTITUTE


LizLand Habitat Model
Uma scoparia
Valley Mountain
Uma Observations (2001)
DRI BLM Plots 2001
MCAGCC RTA's
Habitat Suitability
Suitable Habitat
Moderate to Suitable Habitat
Sub-Marginal to Moderat Habitat
Unsuitable Habitat
N
250 0 250 500 750 Meters
October 2002
DRI
Desert Research Institute
The Redlands Institute



California GAP Habitat Suitability Model

Uma scoparia

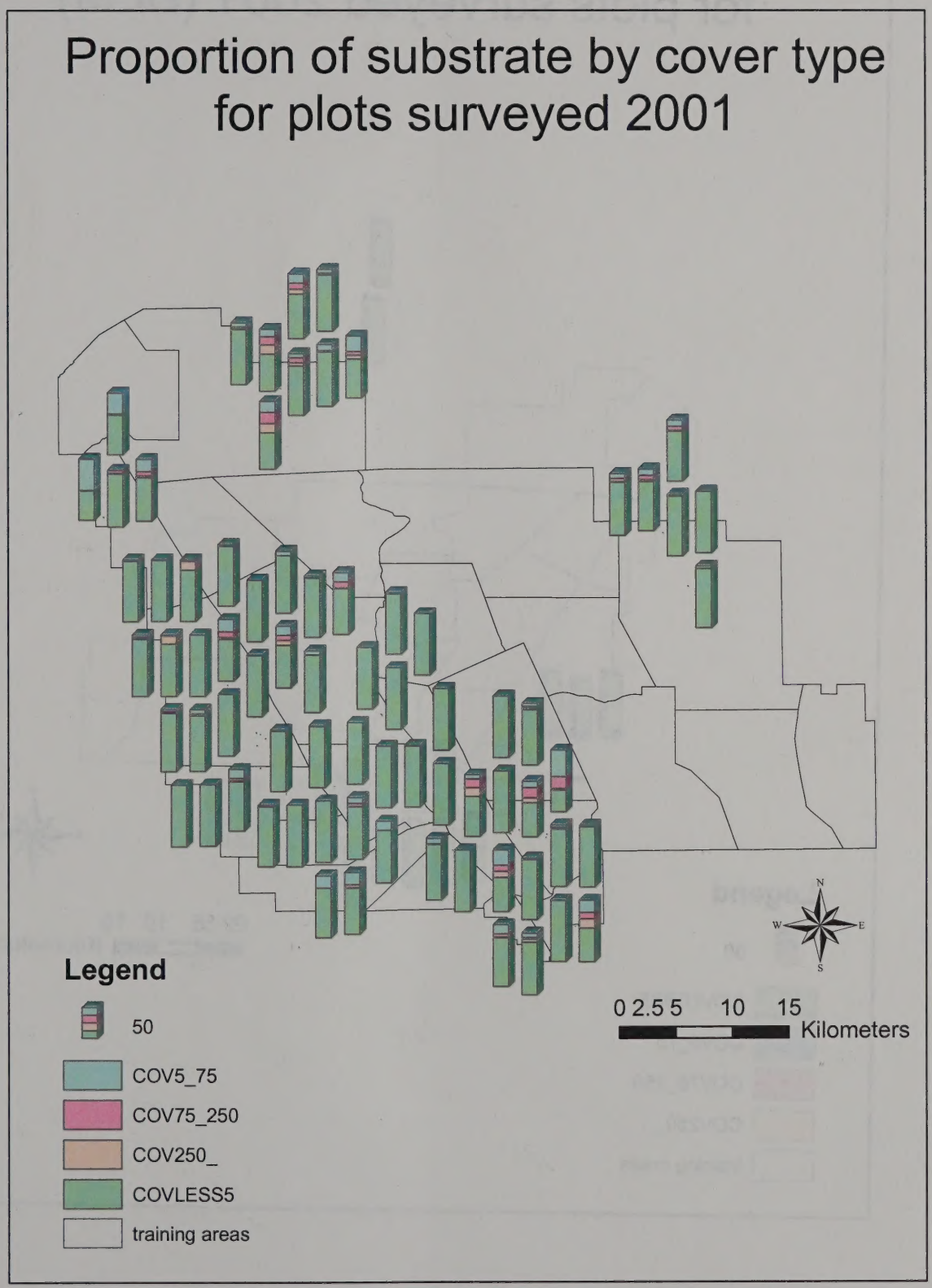
California GAP (CA-GAP) classifies 29 different habitat types in the California Mojave Desert (CMD), Desert Scrub (dominated by Larrea tridentata) accounts for 78% of the total; add Alkaline Scrub and these two classes make up 89% of the total land area. Barren and Pinyon Juniper each total 2%, seven classes each represent 1% and the remaining 18 cover less than 1% each. For MCAGCC only four CA-GAP habitat types exist: Desert Scrub (93%), Alkaline Scrub (4%), Barren (2%) (which in the case of MCAGCC represent three separate lava flows) and Urban (1%).

Habitat suitability

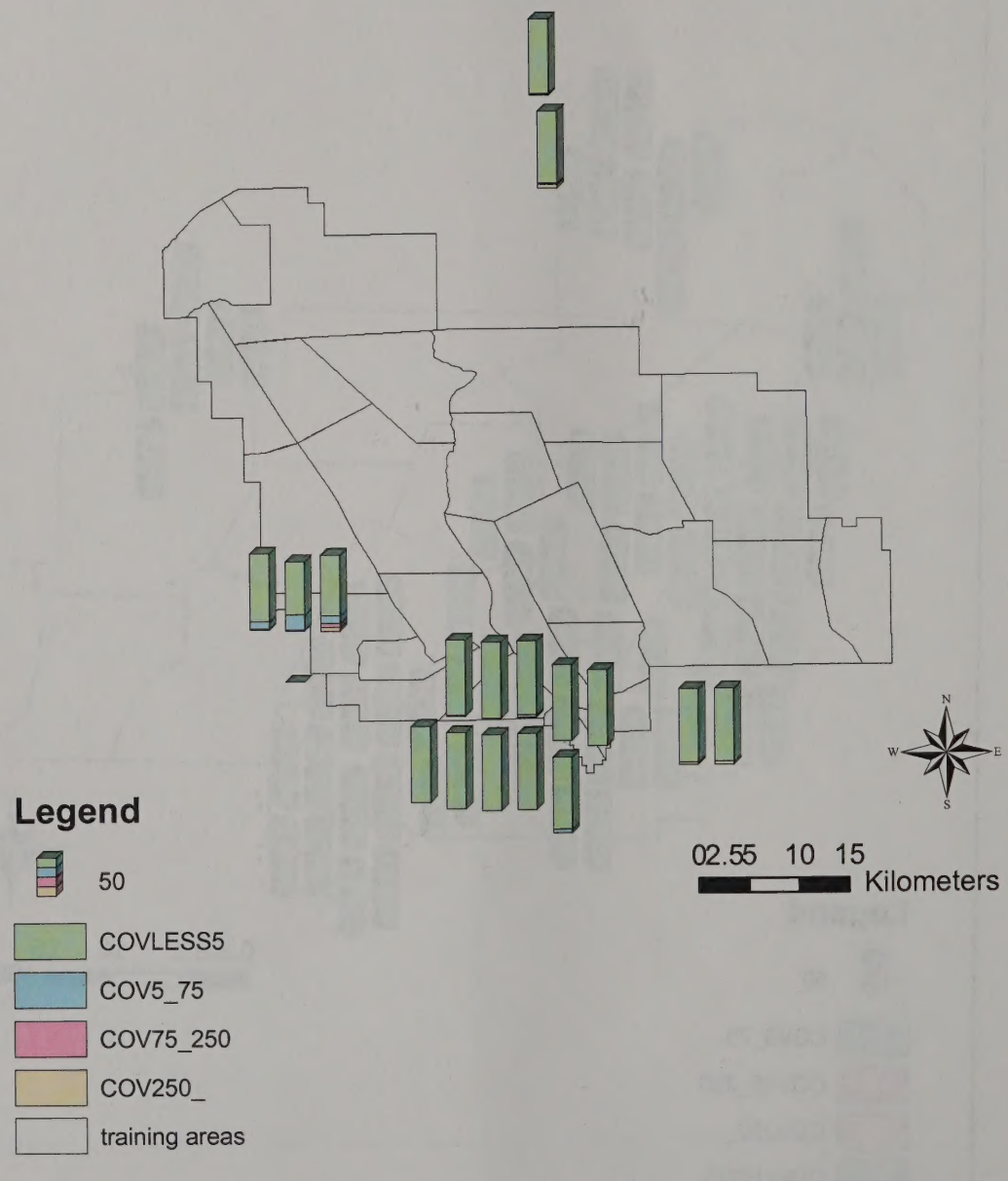
- >50% high habitat suitability
- >50% medium or high habitat suitability
- <50% low, medium, or high habitat suitability
- Unsuitable habitat
- MCAGCC RTA's

Figure 28. California GAP model for *Uma*.

APPENDIX 4.


Proportion of substrate by cover type for plots surveyed 2001
N
W
E
S
Legend
50
COV5_75
COV75_250
COV250_
COVLESS5
training areas
0 2.5 5 10 15
Kilometers

Proportion of substrate by cover type for plots surveyed 2001 (BLM)



Proportion of substrate by cover type
for plots surveyed 2001 (BLM)